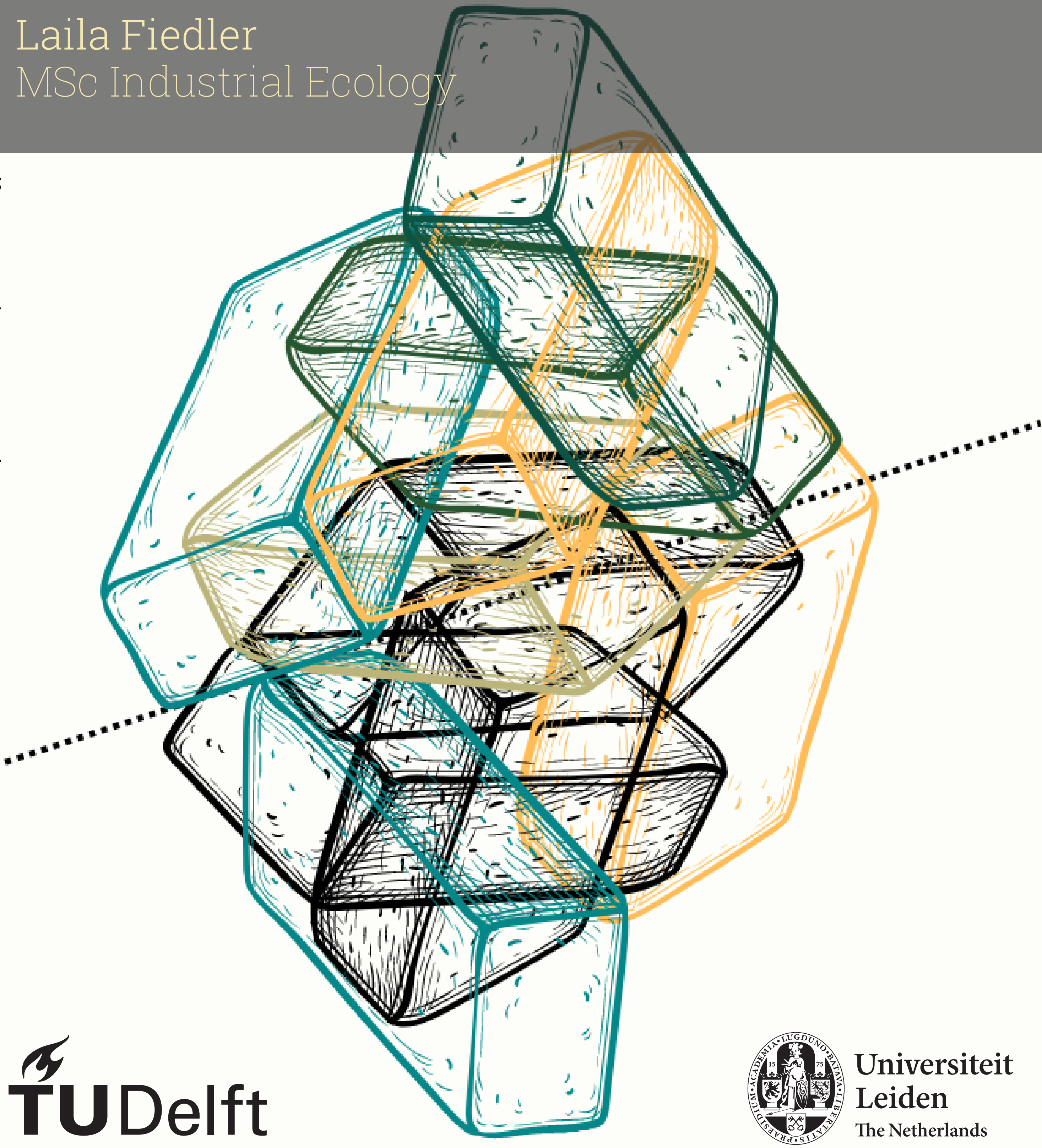
The social impacts of urban densification in times of climate action

Laila Fiedler

MSc Industrial Ecology

Leiden University | Delft University of Technology



TU Delft

Universiteit Leiden
The Netherlands

The social impacts of urban densification in times of climate action

Creating a knowledge base on the social impacts of urban interventions pursuing simultaneous densification, the energy transition and climate change adaptation and comparing the extracted main points with the perceptions of urban policymakers in Amsterdam, The Netherlands

by

Laila Fiedler

to obtain the degree of Master of Science
in Industrial Ecology
at Delft University of Technology and Leiden University,
to be defended publicly on November 23, 2023 at 15:00 PM.

Student number TU Delft:	5667178	
Student number Leiden University:	3368947	
Project duration:	April 2023 – November 2023	
First supervisor:	Dr. T. Verma	TU Delft
Second supervisor:	Dr. N. Y. Aydin	TU Delft
Additional support:	Dr. D. Hogendoorn	City of Amsterdam

An electronic version of this thesis is available at http://repository.tudelft.nl/.

Acknowledgements

I stumbled across the web-page of the Industrial Ecology MSc programme one afternoon in early summer 2021 when the future could have gone many ways. Moving to the Netherlands had not been on my list until that day. But the programme caught me, I felt enticed by the multidisciplinary ideas and the conviction: you need to consider the system as well as you can, otherwise your great ideas will not stand a chance.
At the end of this thesis project I can say that sending this application was absolutely the right choice. I am not going to neglect that there were challenging moments. But, from the beginning, I never felt out of place. It all seemed to add up. And that is extraordinary.

But, I would not be able to write these paragraphs if it had not been for the best support system that I could have wished for.
I would like to thank my supervisors Trivik and Nazli. Trivik, you thought of me when you heard of a qualitative research question in the urban sphere, invited me to the CUSP community and supported me patiently during this long path. Nazli, I would like to thank you for your great work as second supervisor, you were there to provide me with input and advice exactly in the moments I needed them. To all interview participants I want to express my gratitude for sharing your knowledge and insights which got me hooked and which were substantial to this project. I am also grateful for all the discussions, reflections and work with the members of CUSP and the IE community of CML Leiden: keep on questioning and aiming for the understanding that is needed in this world!
The ones that really made me stay and get here are my wonderful friends. Friends that have been accompanying me for the past almost 20 years, and we still make it work to be there for each other. Friends that have borne with me since my first years at university, who always have an open ear to share laughs and the irony of life, no matter how chaotic the situation. Friends that have shaped me during my years abroad who will always be a part of why I want to understand the connections. Lastly, the friends in Leiden and Delft. You made this the enriching, loving, inspiring and fun experience it was - grazing the world of industrial ecology, our homes and the Netherlands. You helped me in the mentally and physically challenging times and without you, these past two years would have been so much less of an enjoyable journey. I wish the best to all of you from all my heart.
Lastly, I want to thank my family. I strode out into the world so many years ago without knowing what it might hold for me. You really gave me all I needed and so much more. You have been my caring companions no matter how many kilometers separate us. You enable me to be the happy person I am and still catch me when I fall.

And once again, I am setting a foot out the door and in whatever may come,
Thank you.

Summary

The global and urbanised population are growing. Densification, the increase of built environment elements in urban areas, has been identified as a tool to mitigate social and environmental consequences of urban sprawl, i.e. the continuous extension of urban boundaries and dispersed construction of built-up areas. At the same time, unique environmental and social challenges are requiring urban developers to adapt their approaches to changed long-term or short-term physical conditions while considering the social consequences. Many cities around the globe, and amongst them Amsterdam, The Netherlands, are striving to align urban interventions in the field of densification and climate action. This led to the research question: Which social impacts arise from simultaneous urban densification and climate action in the form of climate change adaptation and the energy transition?

This study provides insight into the current knowledge in scientific literature and the perceptions of urban policymakers. A qualitative mixed methods approach was applied to answer the posed research question. The approach was constituted of a systematic literature review and semi-structured interviews. A social impact framework was combined with an understanding of the natural sciences, engineering and urban planning to assess the social impacts of urban densification in times of climate action.

Conceptualising the energy transition and climate change adaptation as representative transitions of climate action, I first collected the current literature at the interface of these transitions with densification to compile the perspective of academic literature in a knowledge base. Secondly, I conducted semi-structured interviews with urban policymakers of the Dutch capital of Amsterdam to gain insight into the perspective of policymakers. In the analysis of both my data sets, I discerned explicitly mentioned social impacts as well as social impacts which were not explicitly stated, but could be reasoned from the collected literature and the conducted interviews.

Finally, the comparison of both perspectives shows a strong prevalence of social impacts in the spheres of livability in the built environment, health and economic relations. How densification, the energy transition and CCA in cities exert consequences on communities and institutional relations is much less observed at the current state. Lastly, impacts on cultural or gender relations are close to absent from the discussion - in academic literature and the perceptions of urban policy-makers in the case study alike.

While the results are largely connected to the conceptualisation and methods applied, implications can be drawn for future research and policy-making. It is essential to explore the origins of the low occurrence of cultural and gender impacts in the data set to evaluate whether these are due to knowledge constraints or actual low impact rates. But, given the understandings gained, I urge to observe these spheres more strongly, in particular in relation to indirect social impacts. Moreover, the case study shows that social impacts of densification and climate action transitions are highly context-driven. They are subject to questions of ownership, human behaviour, urban inequalities and social differentiation within the constraints of physical space and monetary as well as environmental budgets. Additionally, it is indispensable to further strengthen the interaction and communication between researchers, policy-makers and other stakeholders.

To conclude, future research and policy-making could use the generated knowledge base and the results and context provided by the case study to achieve more socially sustainable urban planning.

Keywords: Urban densification, energy transition, climate change adaptation, social impacts, Amsterdam, urban policy-making

Contents

Nomenclature

Abbreviations

Abbreviation	Definition
2D	two-dimensional
3D	three-dimensional
AMR	Amsterdam Metropolitan Region
BE	Built environment
BD	Biodiversity
BDI	Increase of urban biodiversity
CA	Climate Action (CA = ET + CCA)
CC	Climate Change
CCA	Climate Change Adaptation
CCM	Climate Change Mitigation
CE	Circular Economy
CM	Conceptual Map
DMP	Data Management Plan
EC	European Commission/Commission of the European Union
EIA	Environmental Impact Assessment
ES	Ecosystem services
ET	Energy Transition
EU	European Union
EV	Electric vehicles
FMC	15-minute City
GHG	greenhouse gas
HREC	Human Research Ethics Committee
IC	Informed consent
ICF	Informed Consent Form
IE	Industrial Ecology
IPCC	Intergovernmental Panel on Climate Change
LU	Leiden University
m	Meter/meters
MENA	Middle East and North Africa
NBS	Nature-Based Solutions
NL	The Netherlands
OV	*Omgevingsvisie* (Spatial Vision)
PV	Photovoltaic
RFD	Research Flow Diagram
RQ	Research question
SDGs	Global Sustainable Development Goals
SI	Social impact category
SIA	Social Impact Assessment
SRQ	Sub-research question
TU Delft	Delft University of Technology
UGI	Urban green infrastructure
UGS	Urban green space
UHIE	Urban Heat Island Effect
UK	United Kingdom
UN	United Nations

Abbreviation	Definition
UNFCCC	United Nations Framework Convention on Climate Change
USA	United States of America
VVE	Vereniging van Eigenaren (Owners' Association)

Chapter 1

Introduction

1.1. Context: urbanisation and global resource use

The headlines about the **growing and urbanized world population** have been recurring in scientific, political and media discourses. They decorate entrance slides in conference presentations, policy paper introductions and news programmes (European Commission - Competence Centere on Foresight, 2020; European Commission-Joint Research Centre, 2023; Swilling, 2016; The World Bank, 2023a, 2023b; UN DESA | United Nations Department of Economic and Social Affairs, 2018).

It can be assumed that each urban (or non-urban) resident strives for **a happy and just life**, including shelter, food, drink and other materials, as well as immaterial resources. This means, that land is used to live, harvest and mine. But at this stage of the Anthropocene, 2023, the safe and just operating space on Earth has been pressured to such an extend, that out of the eight quantified global earth system boundaries seven have been transgressed (Rockström et al., 2023, p. 8), see Figure 1.1. Despite the natural uncertainties of the models, these results continue to pose a clear warning. To stay within planetary boundaries, **we need to vastly change how natural resources are used** (Haberl et al., 2021; Rockström et al., 2023; Rockström et al., 2009; Steffen et al., 2015). **And this includes land**.

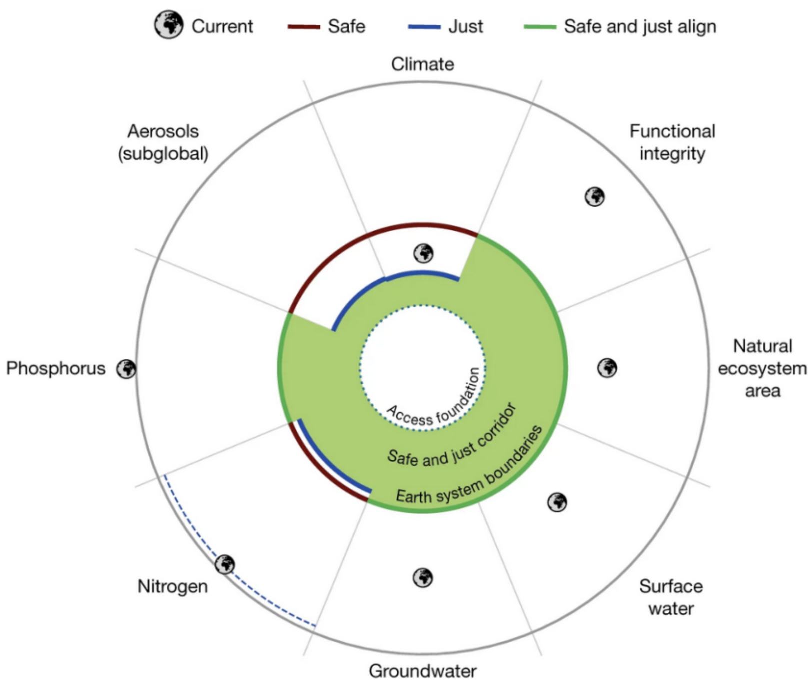


Figure 1.1: Proposed safe and just operating space (green areas) vs. current global states (Earth icons). Dark red lines are safety limits and blue lines justice limits. Figure from Rockström et al. (2023).

1.2. Urban Densification

Densification, the agglomeration of population in one area instead of a development based on urban sprawl, has long been seen as an urban development pathway reducing resource use, and in particular the use of land. Densification is aimed at the reduction of land use for urban built structures to relieve pressures on the "natural" environment. As the largest share of greenhouse gas (GHG) emissions in cities is generated in the housing sector, followed by transport emissions (Pichler et al., 2017), these sectors need to be reconsidered. Urban densification may be a powerful tool to rethink housing as well as transport patterns to stay closer within planetary boundaries.
One **potential densification strategy** is the **topping up of buildings**, i.e. the upward extension by several floors. Another one is to **fill in idle space or 'infilling'**, for instance of under-used parking lots, backyards or derelict brownfield areas. Densification for an increase of residential use areas may also be conducted by the **transformation of area functions**. This could mean the transformation from a former industrial or business function, from transportation infrastructure space, or, from green areas to housing. Often, densification is combined with other goals such as the increase of multifunctional and proximate urban spaces. For this reason, it is a paradigm of balancing and accommodating urban functions.
Figure 1.2 shows the idealised built up of a compact, densified city block in the policies of the second largest Dutch city, Rotterdam (Gemeente Rotterdam, 2023). Exemplary (in orange) are the infilled areas, areas of changed function and topped-up housing units.

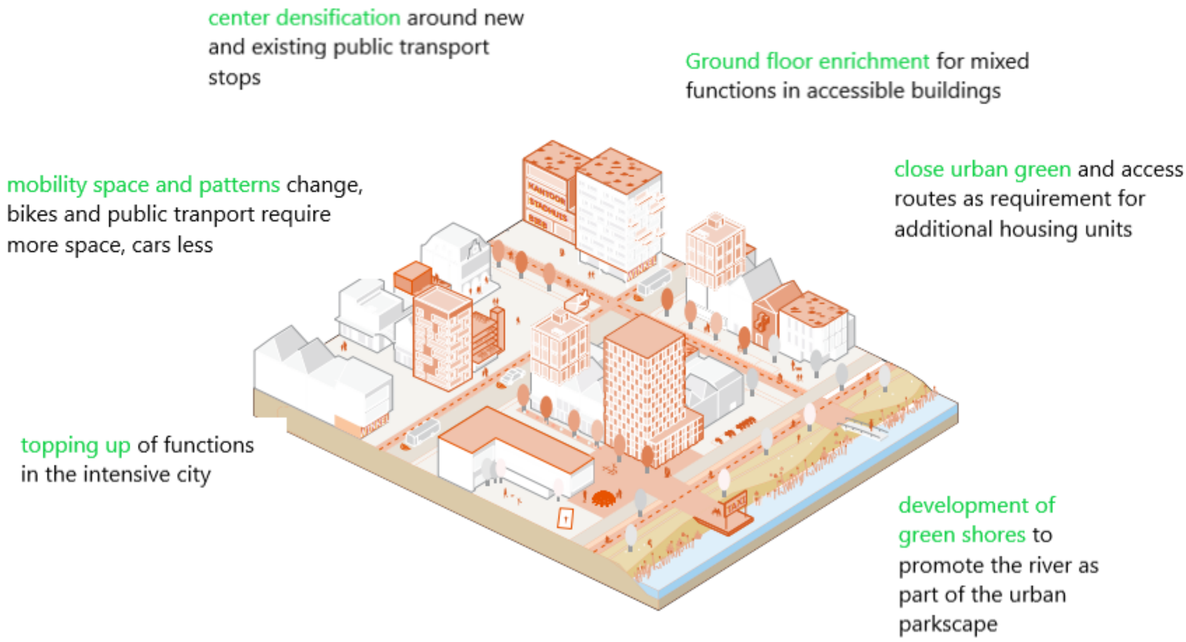


Figure 1.2: The compact city model as envisioned by the municipality of Rotterdam. Lively ground floors, urban green, changed mobility patterns, topping up existing buildings or densification around transportation lines are part of the densified environment (image taken from Gemeente Rotterdam (2023), own translation).

Urban densification is **not a standardised term** (Lehmann, 2019). Next to the terms "urban densification" or "urban compaction", the terms "urban intensification", "urban consolidation" (Ambrey et al., 2017), "(urban) agglomeration" or "urban infilling" are used as well. The "compact city" as an urban form paradigm often stipulates the result of these developments if they are applied at a city-level and complemented by measures of resource use efficiency and accessibility increase (Ahlfeldt & Pietrostefani, 2017). The choice of wording and definition of "density" and "densification" often depends on the author's disciplinary or geographic context or the densification variant under assessment (compare Churchman (1999)). **This thesis will make use of the term "densification".** Should other terms of the above list be applied, they are to be understood interchangeably.
For Bibri et al. (2020) the compact city may be the "central paradigm" (p. 2) of sustainable urbanism. In their layout of the design strategies of the compact city approach, the authors also include the creation

of long-term "resilience and viability through reducing material use, lowering energy consumption, mitigating pollution, and minimizing waste, as well as improving social equity and well-being" (p. 2) into the definition of sustainable urbanism. However, densification **can lead to a number of drawbacks**, such as and in relation to, increased population counts (e.g. resource use, waste, air pollution, insufficiency of services etc.) (Cavicchia, 2023; Haaland & van den Bosch, 2015; Haarstad et al., 2023; Mohajeri et al., 2023; Neuman, 2005).

1.3. Climate Action (CA)

At the same time, urban and non-urban populations are facing unique challenges, amongst them the consequences of a warming global climate, climate change (CC). To adapt to and mitigate CC, measures are being taken by organisations, governments, corporations or individuals, activities which can be summarised as **climate action (CA)**.
CA is a vast term. In the definition of the United Nations' (UN) Sustainable Development Goal (SDG) Number 13 it is described as embarking on activities aimed at combating climate change and its impacts. For instance, in the latest SDG report, the UN call for a 43 % reduction of GHG until 2030 and the achievement of net zero GHG emissions until 2050 to try to avert the CC impacts as far as still possible (UN DESA | United Nations Department of Economic and Social Affairs, 2023).
The two transitions of **climate change adaptation (CCA)** and the **transition of the energy systems to cut down carbon emissions as far as possible (ET)** can be seen as forms of CA: The Intergovernmental Panel on Climate Change (IPCC) as the leading scientific body on CC emphasises the need for the ET and the adoption of CCA measures (Campos et al., 2014). The United Nations Framework Convention on Climate Change (UNFCC) addresses CC and allocates not only CCA but also the ET under the umbrella of CA (UNFCC, 2021).
In line with the Habitat III-Conference glossary, **"[a]daptation is the process of adjustment to actual or expected climate and its effects."** The glossary furthermore distinguishes between adaptation in human systems and natural systems. While the first "[...] seeks to moderate harm or exploit beneficial opportunities", the second "[...] may facilitate adjustment to expected climate and its effects" (Habitat III Secretariat, 2017, p. 1).
In 2014, Rutherford and Coutard (2014), summarising others, defined **ET as "a radical, systemic and managed change towards 'more sustainable' or 'more effective' patterns of provision and use of energy"** (Rutherford & Coutard, 2014). I want to apply this definition of the ET in my report.

1.4. Social Sustainability

It is important to **evaluate the social impacts of interventions** to estimate their **overall and long-term social sustainability**. It is difficult to conceptualise and measure sustainability, even more so *social* sustainability. The general sustainability understanding I draw from the UN Brundtland Commission. In 1987, the Commission prominently laid out the definition of sustainability as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). As a result, next to ecological and environmental sustainability, my sustainability understanding includes the sphere of social sustainability and regards citizens' rights as crucial for **meeting "the needs of the present" as well as of "future generations"**.
In the understanding of what makes a socially sustainable city I follow the understanding of Larimian and Sadeghi (2021):

"[W]e define a socially sustainable neighbourhood as one that provides residents with equitable access to facilities, services, and affordable housing; creates a viable and safe environment for interaction and participation in community activities; and promotes sense of satisfaction and pride in the neighbourhood in a way that people would like to live there now and in the future" (p. 624).

What can be understood from this quote is the authors' systemic approach. I.e., for an individual's living area to be socially sustainable, a whole mix of connections and services is required. If these prerequisites are fulfilled, the urban environment may provide a living space which is experienced as safe, interactive, participatory and identity-shaping.

1.5. Social impacts and interdependencies

How actions impact society has been observed by research, governments, public or private organizations. Often, social impacts are compulsory to estimate and evaluate in advance of large-scale projects and interventions. **Social impacts** may be defined as including

"all social and cultural consequences to human populations of any public or private actions that alter the ways in which people live, work, play, relate to one another, organize to meet their needs, and generally cope as members of society" (Burdge & Vanclay, 1996).

The alterations as consequences of urban interventions that I want to focus on in my theses are,

*"impacts **actually experienced by humans** [...] in either a corporeal (physical) or cognitive (perceptual) sense"* (Vanclay, 2002, p. 191).

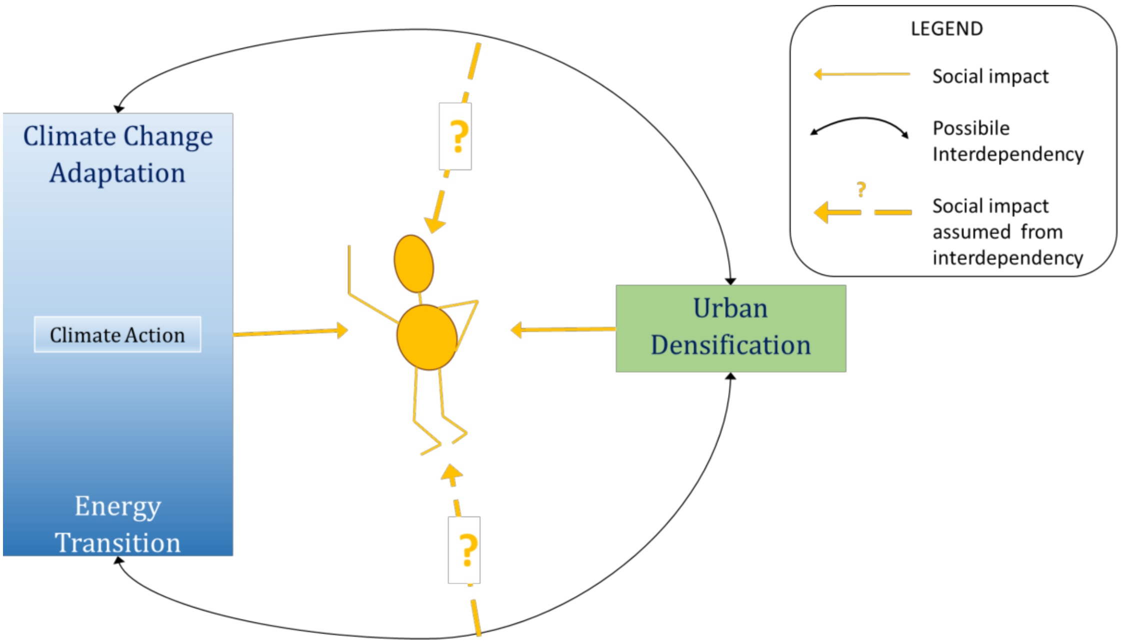


Figure 1.3: Hypothesis: Next to the direct social impacts of each transition (yellow arrows), the assumed interdependencies between densification, CCA and the ET (black arrows) create new social impacts (yellow dashed arrows).

This thesis explores the relationship between urban densification and CA transitions. Urban development in times of CA is set in a complex, socio-technical system, the city. Densification strongly interacts with CA and CCA and the ET respectively: It not only seeks to reduce the expansion of urban land, but also to shape building patterns, urban functions and infrastructures. Simultaneous CA transitions and densification developments evidently compete for urban space, material and immaterial resources, including municipal budgets. Moreover, each intervention in the urban space, affects urban residents, their daily experiences, routines and behaviour, i.e. exerts social impacts, see Figure 1.3. Altogether they compose firstly, a variety of competing policy interests in urban development and planning, and secondly, a variety of impacts on the social dimension arising from these interactions or **"interdependencies"**.

1.6. Research objective and research question (RQ)

My objective is to collect and describe current knowledge about **the social impacts arising from a parallel pursuit of urban densification** for the prevention of urban sprawl **and CA, in the form of CCA and the ET**. The underlying understanding is that the social dimension is an integral part of sustainability and that **no action with the goal of sustainability can be successful if the intervention is not socially sustainable as well**. For this reason, if densification, ET and CCA interventions are to be successfully implemented, the social impacts need to observed.

In particular, the objective is to collect the **scientific knowledge** on the social impacts of densification in times of CA and to **compare this knowledge base with the perceptions and experiential knowledge of urban policymakers.** For this reason I will first review the current state in literature and then zoom into the **case of the city of Amsterdam,** the largest city in the Netherlands.

My research will be guided by the **research question (RQ)**:

Which social impacts arise from simultaneous urban densification and climate action in the form of climate change adaptation and the energy transition?

1.7. Relevance to the field of IE

The RQ is of high relevance to the field of Industrial Ecology (IE) and **IE may vice versa provide a suitable lens** for the understanding of the issue at hand: The scientific field of IE quantifies and qualifies flows through human-made (therefore industrial) systems (therefore ecology). The IE toolbox holds a set of **multi- and interdisciplinary scientific methods** for this aim (International Society for Industrial Ecology, 2023). While this might suggest an **engineering and natural science** approach, the discipline at the same time takes a thorough look at **interconnections with the social system**, such as drivers in and consequences of a process for society.
Cities are a prominent research subject within IE (Kennedy et al., 2015): **as highly complex socio-technical systems cities pose manifold intertwined challenges**, so-called "wicked" problems (Hughes, 1989). Cities inherently occupy the planet's surface and affect the "natural" environment. They are composed of structures in the built environment and other physical infrastructures, for instance water, electricity or transport grids. Moreover, cities depend on inflows, accumulate stocks and release substances as outflows to their surroundings. This has been termed the "urban metabolism" (Kennedy et al., 2015; Y. Zhang, 2013), one of the major IE concepts.
Humans agglomerate in cities voluntarily or involuntarily for reasons of shelter, jobs, trade or other social functions and services. In general, one or several entity/-ies in power impose(s) rules over this created system. As these rules depend on the characteristics of the entity, population and context in which the agglomeration is set, urban space and organisation are connected to various questions of societal justice and equality. Such fundamental considerations ought to underpin any IE research approach as they inherently pose the question who benefits and who loses in the strive for sustainability (International Society for Industrial Ecology, 2023).
Also the motivation for urban densification strategies arises from a complex web of social, technological and environmental demands and needs. The same accounts for the societal transitions within CA. A synthesis of the current scientific knowledge of the system interdependencies between urban densification strategies, CA and social impacts qualifies this thesis topic as a wicked problem of high relevance to the field of IE.

1.8. Thesis outline

In the next chapter I further conceptualise social impacts, urban densification and the CA transitions. Moreover, I lay out previous work on the social implications of urban densification. Having attained this knowledge, Chapter 2 closes with stating the research gap, research design and the sub-research questions (SRQs). Chapter 3 includes background literature to the social impact understanding applied in this thesis. Thereafter, you will find the applied methods in Chapter 4. The results and analysis of the collected data are given in Chapter 5 (literature review) and Chapter 6 (case study). In Chapter 6, I also describe the case further. The divergence and overlap of the results of the two methods I present in Chapter 7. The discussion of this observation and the limitations of my study as well as its implications for further research and urban planning form Chapter 8. The final answers to the RQ and SRQs round up this thesis in the conclusion in Chapter 9.

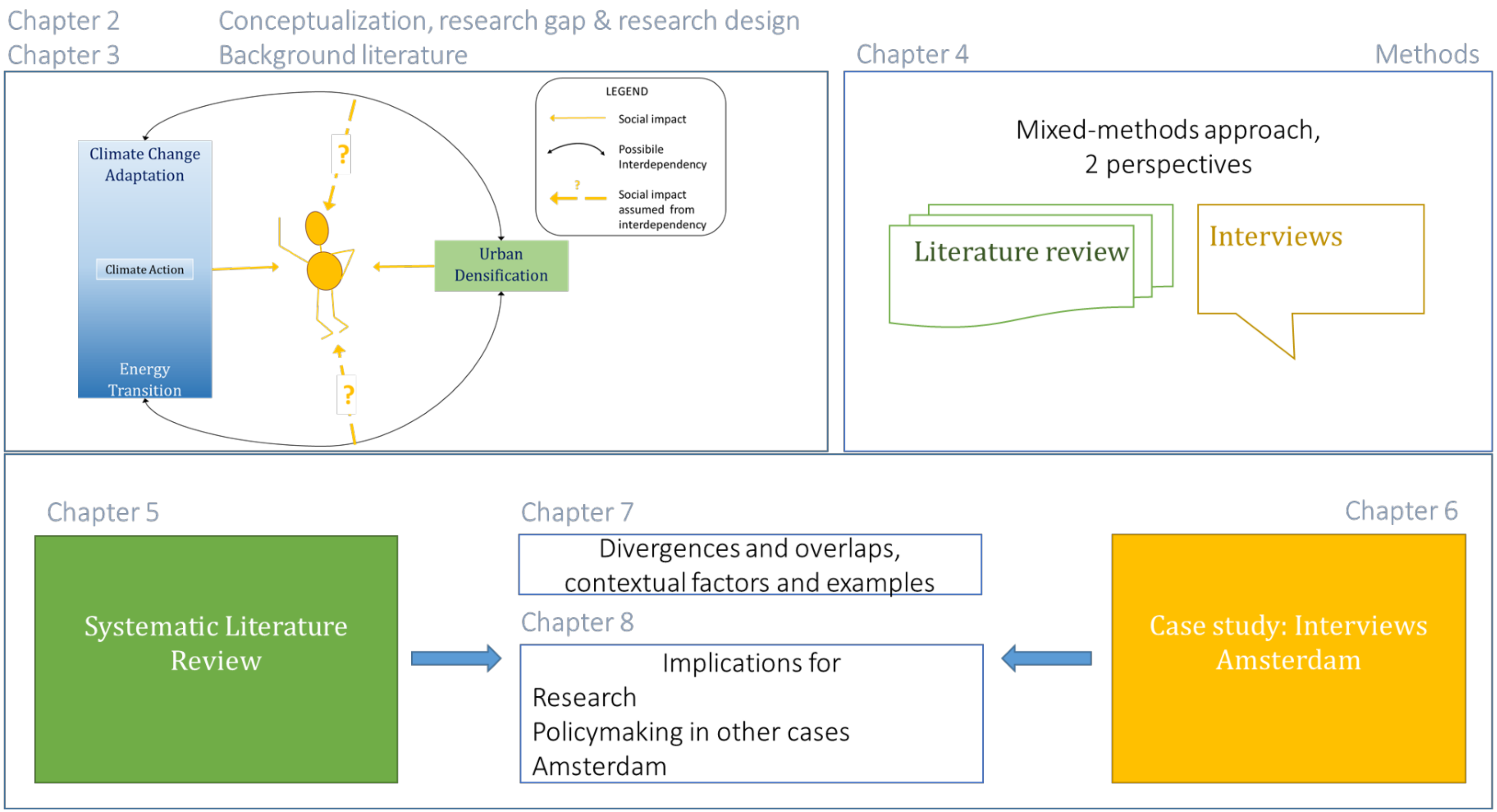


Figure 1.4: Outline of the report at hand. The thesis report includes 9 chapters: 1) Introduction, 2) Conceptualization, research gap, research design and SRQs, and 3) The social dimension- theoretical background. This is followed by the 4) Methods, 5) Literature review, 6) Case study, 7) Vice-Versa: Divergences and Overlaps, 8) Discussion, 9) Conclusion.

Chapter 2

Conceptualisation and Research Gap, Design, and Sub-Questions

In this chapter I introduce the conceptualisation of social impacts that I applied in this thesis, i.e. the social impact framework of Vanclay (2002) and the social impact and social change process definition of Slootweg et al. (2001). Then, I provide my understanding of densification, the ET and CCA as CA transitions for the scope of this thesis, starting in Section 2.2. This is followed by an overview of a selection of previous work on the social impacts of the three transitions. In the last Section, 2.6, I present the sub-research questions (SRQs), scope and research design for the exploration of the research gap (RG) and the RQ which my thesis aims at contributing to answer.

2.1. Social impacts

2.1.1. Vanclay and Slootweg's framework of impacts and impact processes

A distinction between **biophysical impacts, social impacts** and **social and biophysical change processes** is important (Slootweg et al., 2001), see Figure 2.1. However, there might be interaction between these spheres. As this figure shows, (urban) interventions, either in the biophysical or social dimension, can create or affect social change processes. A biophysical urban change process may lead to a social change process. These social change processes may generate human (social) impacts, which are "experienced or felt in corporeal or perceptual terms" (Vanclay, 2002, p. 200).

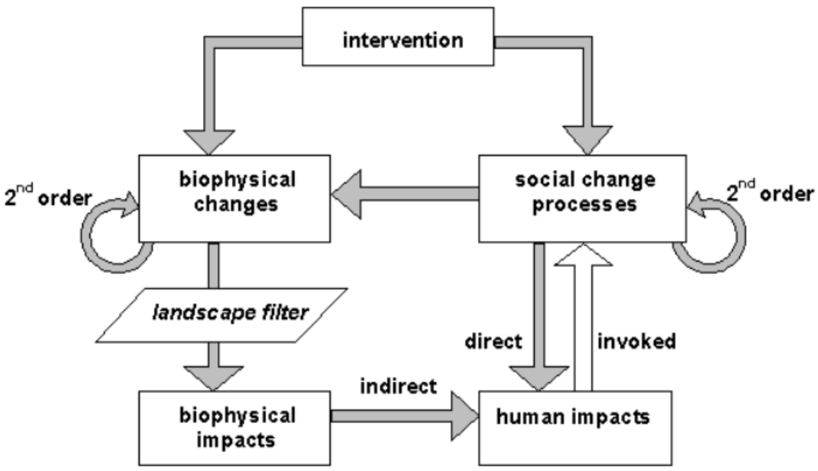


Figure 2.1: Slootweg et al. (2001, p. 26) visualising pathways to derive biophysical and human impacts. Interventions trigger social and biophysical changes. Resulting biophysical and human (= "social") impacts may be of first or second order, direct or indirect.

In the categorisation of social impacts, it needs to be understood that there are **first and higher-order** social impacts. Impacts may generate iterations and feedbacks of social impacts and change processes. Relationships between the impacts and one impact may trigger another social change process, which then again results in a second- or higher-order social impact (Slootweg et al., 2001; Vanclay, 2002). **This project will observe the social impacts generated through the interplay of the socio-technical and ecological change processes of urban densification and climate action**, with a **focus on the seven social impact categories (SIs)** as established by Vanclay (2002). Table 2.1 displays these seven SIs observed in this thesis: 1) health, 2) livability, 3) economic relations, 4) culture, 5) community, 6) institutional, 7) gender relations (Vanclay, 2002). The second column lists the number of the individual social impacts per SI. The full list of SIs and individual social impacts per SI is included in Appendix A.1.

Table 2.1: The seven social impact categories (SIs) derived from the framework of Vanclay (2002) and the number of individual social impacts per SI applied in this thesis.

Social impact category (SI)	**Social impacts in SI**
Community (indicative family and community impacts)	10
Culture (Indicative cultural impacts)	7
Economic relations (indicative economic impacts and material well-being impacts)	14
Gender (indicative gender relations impacts)	9
Health (indicative health and social well-being impacts)	13
Institutional (indicative institutional, legal, political and equity impacts)	8
Livability (indicative quality of the living environment impacts)	13

2.1.2. Use and limitations of the framework

Assessing qualitative impacts quantitatively is difficult and leads to an evident reduction of reality. The social impact categories include non-quantifiable impacts. The quantification is an approximation to their true complexity. Therefore, Vanclay (2002) urges caution in using the framework as a checklist and also acknowledges the perpetuation of social impacts and processes by declaring that "[m]ost social impact specialists stress that it is impossible to detail all dimensions of social impacts — social change has a way of creating other changes" (p. 185). Hence, social impacts are context-driven, context-, and subject-specific (Vanclay, 2002, p. 188).
Furthermore, Vanclay highlights that the lists of social impacts created are naturally subject to the context, bias and prejudice of the author and their field.
Thus, while Vanclay's categories can never amount to a complete picture of how urban densification as a project influences society and local communities, I chose the categories to allow for a systematic and manageable analysis.

2.2. Urban densification

2.2.1. Conceptualising urban densification: variants and features

Urban density can be measured in physical categories, such as density of population, number of dwellings, or economic densities, for instance number of jobs and amenities. However, densifying the built design of urban neighbourhoods alone will not be able to generate a sustainable city.
The urban development **process of urban densification** as applied in this thesis is a physical process which can be conducted in various ways, but which aims at the promotion of a city with neighbourhoods featuring multifunctional uses, going beyond an agglomeration of built structures. Amongst these are i.e. the creation of walkable neighbourhoods, a variety of transportation choices or community and stakeholder collaboration in development decisions (Habitat III Secretariat, 2017, p. 2-3).
In 1973, Dantzig and Saaty (in Bibri et al. (2020)), summarised the densification characteristics, see Table A.2 in Appendix A.2. Their definition of a densified city, even though until now critically reviewed, results from **urban form and spatial features as well as social functions**. In 2017, Ahlfeldt and Pietrostefani (2017) roughly determined the economic and morphological density and mixed land use characteristics which make up the compact city as dense urban form.

For this project, I want to apply the urban densification understanding as in **figure 2.2. It shows the variants and features** I am focusing on. Next to **variants of topping up of buildings, infilling and area**

transformation, I discerned the features of mixed land use, settlement density, low-impact mobility and proximity of functions from the literature I studied (Ahlfeldt & Pietrostefani, 2017; Bibri et al., 2020; Haarstad et al., 2023; Mohajeri et al., 2019; Mouratidis, 2018; Neuman, 2005; Westerink et al., 2013).

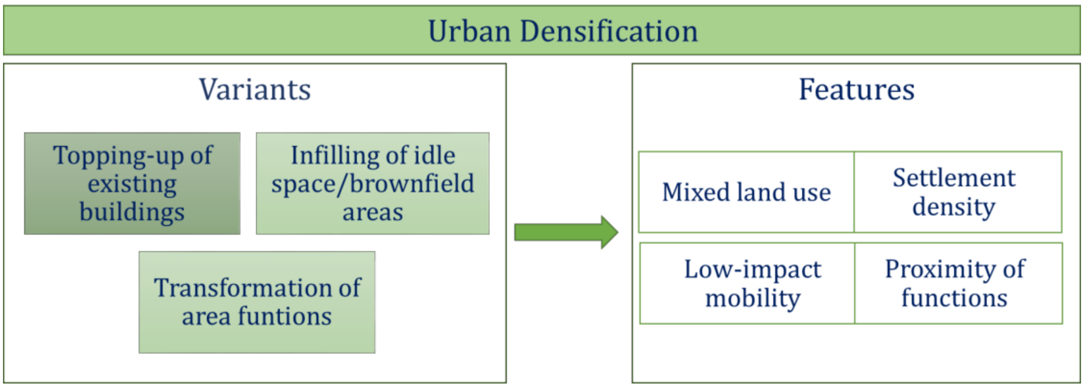


Figure 2.2: Zooming into the densification variants and the features discerned from the studied literature observed in this thesis.

2.2.2. The social impacts of urban densification in previous works

Densifying city planning has been hauled as solution for the planning of environmentally sustainable cities (Byrd & Ho, 2012). However, criticism of this planning doctrine as an unachievable ideal has been brought forward too. Not least in 2005, Neuman (2005) elaborated about the "compact city fallacy" and criticised, that urban form alone could not be seen as a certain determinant of sustainable urban development (p. 23). Several other authors followed (Bibri et al., 2020; Byrd et al., 2013; Cavicchia & Cucca, 2020; Latasa & Laurenz, 2023; Lehmann, 2019; Muñiz & Dominguez, 2020; Næss, 2014)).

In their 2021 study, Larimian and Sadeghi (2021) developed a framework for "a comprehensive and multidimensional scale for measuring urban social sustainability (USS) at the neighbourhood level" (Larimian & Sadeghi, 2021, p. 622). Their framework comprises seven social sustainability dimensions, namely: neighbourhood satisfaction, sense of place, safety and security, social equity, social interaction, housing satisfaction and social participation. Their understanding therefore stems from a social satisfaction rooted in the social facet of the urban built environment.
A resident's perception of the neighbourhood and its functions for physical and mental well-being, self-fulfillment and security are central to their measurement variables (Larimian & Sadeghi, 2021, p. 628). The authors founded their work on previous studies by Bramley et al. who raised the functions of viability, long-term setting for cultural development, human interaction and communication as determinants of urban social sustainability, as well as Hemani et al. who highlighted that "creating urban spatial forms that nurture[...] the 4 's', social capital, social cohesion, social inclusion and social equity" through "a combined top-down and bottom-up process". Lastly they divide research on the sustainability of cities into studies at the macro level (region and city) and micro levels (community and neighbourhood) (Larimian & Sadeghi, 2021, p. 623).

In their literature review and subsequent comparative case study Westerink et al. (2013), showed at the example of four European regions, that densification planning for the goal of a compact city can lead to adverse effects on sustainability, which they categorised into social, environmental, economic and resilience aspects. Each of the aspects was analysed at the hand of indicators defined to be distinguishable in a compact vs. dispersed city (Westerink et al., 2013, p. 478).

Ahlfeldt and Pietrostefani (2017), categorized literature analyses (n = 201) along 15 outcome dimensions, in which literature expected certain theoretic impacts of densification, i.a. access to jobs and services/amenities, social equity, safety, open space, mode choice, and health. The connections that were based on scientific theories, were tested against the results of empirical analyses in case studies (n = 321). This evaluation presented a divergence of scholars' expectations and the empirical studies.

In their evaluation of policymakers' expectations about urban densification measures' impacts against the insights gained from a literature review (n = 229, global scope, peer-reviewed empirical studies), Berghauser Pont et al. (2021) concluded a clear misalignment of planners' expectations and peer-reviewed work on the effects of urban density. The group summarized the empirical evidence under the themes of public infrastructure, transport, economics, environmental impact, social impact and health impact, each of the categories comprising at least three indicators (Berghauser Pont et al., 2021, p. 384). In the second step, this work showed impressively, that amongst the Swedish planners consulted to gather the motivations between the densification plans, the expected social and economic impacts were estimated much more positive, while the environmental impacts were believed to be more negative than the literature review suggested. This study spotlights that there is an evident divergence between scientific knowledge and urban planning practice expectations. Even the results of this test cannot be generalised and needs to be seen at the background of the Swedish context, it might still be considered impressive due to the strong standing of Swedish urbanism scholarship and policies.

In 2014, Næss (2014) reviewed the literature on the health impacts of urban form and evaluated these against a case study of Oslo. The indicators considered in this study were district density, location relative to the city center, number of dwellers per dwelling, percentage of intra-urban green areas and bordering surrounding forests to the districts. Several socio-economic variables were included as explanatory variables to identify the dependent health variable, life-expectancy was identified along cardiac infarcts per 10,000 inhabitants and as intermediary variable between built environment and health, the exposure to noise. The results of the study are adding to the complex observation of the impacts of densification. While it may lead to increased outdoor activity of residents, the location of sufficient work places and the character and quality of the transport system within the city and beyond are decisive for the residents' health.

2.3. The Energy Transition (ET)

In global policymaking, SDG 7 calls for ensuring "access to affordable, reliable, sustainable and modern energy for all, with the sub-goal 7.2 of substantially increasing renewable energies' share in the global energy mix. To **reduce GHG emissions and increase energy efficiency** requires a reconsideration of **provision and use of energy** (Rutherford & Coutard, 2014). Globally, the share of renewable energies has been growing, shifting the energy system slowly towards large electricity infrastructures (International Energy Association (IEA), 2021).
In urban contexts, the emissions generated over the whole life-cycle of the building stock are immense. Construction, heating, cooling, and other forms of use and maintenance that consume energy contribute vastly to the global energy emissions (C40 cities, 2023; Kennedy et al., 2015; Pichler et al., 2017). In this thesis I will look at the sectors of mobility, residential heating and cooling, urban energy production and the urban energy grid. I will not look at production, manufacturing, waste, amenities (incl. food and feed), services and construction. Figure 2.3 shows the sectors and features of the ET that I include in my scope for this transition. The figure is based on Table A.3 in Appendix A.3.

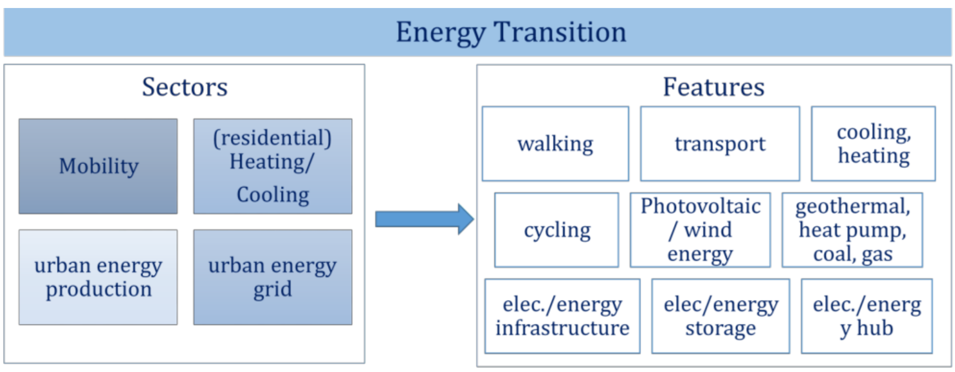


Figure 2.3: Zooming into the ET sectors and features observed in this study, compare C40 cities (2023), Kennedy et al. (2015), and Pichler et al. (2017).

2.4. Climate Change Adaptation (CCA)

Urban CCA plans are established globally (Pörtner et al., 2022, p. 71) and SDG 11.b. calls for the adoption and implementation of "integrated policies and plans towards [...] **mitigation and adaptation to climate change, [and] resilience to disasters"**. Many cities globally engage in CCA to adapt their built and social structures to changed circumstance. With the evolution of cities throughout the centuries and the current consequences of CC, material and immaterial infrastructures are in need of adjustments.
Within my scope I will look at the sectors of CCA management, thermal comfort, flooding and drought. Figure 2.4 shows the CCA sectors and features that I included into my scope, based on Table A.4 in Appendix A.4.

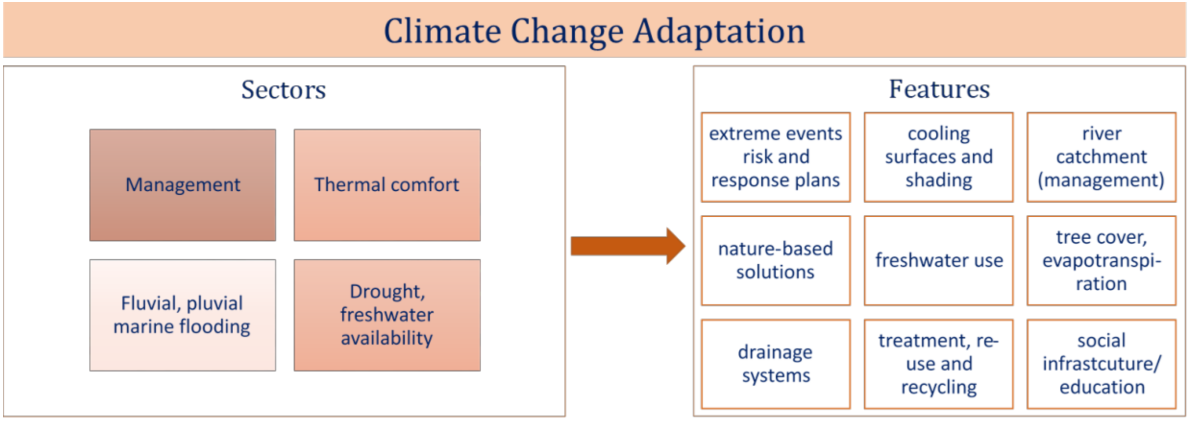


Figure 2.4: Zooming into the CCA sectors and elements observed in this study, re-conceptualised and adjusted to scope from C40 cities (2023).

2.5. Climate Action: climate justice and vulnerability

CA (in my thesis: CA = ET + CCA) strives to avert and alleviate the consequences of CC. Thereby it could be assumed that it was inherently socially sustainable. However, reviewing works on the social sustainability of CA, the concepts of climate justice and vulnerability are essential.
In this project I draw from Adger et al. (2009) and Duus-Otterstrom and Jagers (2012) as in Byrne et al. (2016),

> defining **climate justice** as "[referring] to efforts to overcome the inequitable distribution of climate change burdens and benefits among populations, and also to actions intended to remedy unfair responsibilities for mitigation and adaptation [...]" (p. 1).

In the urban context, even the much smaller neighbourhood or city scale can lead to unjust impact distribution. As Williams et al. (2023) have pointed out for the case of public health: "current planning efforts to improve public health mainly consider how social and environmental factors directly affect health of populations as opposed to evaluating how these decisions *alleviate or exacerbate existing inequalities within populations*" (p. 167, emphasis added).

These "existing inequalities" are essential, as they lead to differing levels of resident **vulnerability**. How much a resident is affected by a changed situation depends on their sensitivity and susceptibility on the one hand. On the other hand it is decisive whether the group or individual can cope with a changed situation and/or adapt to it. Combined, the sensitivity/susceptibility and adaptability/coping capacity determine the residents' vulnerability. Following Campos et al. (2014), Habitat III Secretariat (2017), and Tapia et al. (2017), the exposure and hazard factors multiplied with the vulnerability factor results in the risk faced. How I stated climate justice in the paragraph above however is a simplification. Not alone climate justice incorporates several dimensions, but also inequality in the context of CC and environmental impacts is a broad term. Whether it is about the distribution of causes, impacts, monetary or non-monetary costs, policies, institutional processes or recognition in environmental change processes, these are issues of **inequality in climate justice** (Heyen, 2023). The complexity of socio-technical systems (i.e. systems, where society and technology interact, drastically, any human-made system based on technological items) and the uncertainties in the future development of CC suggest the remit that any CA most certainly also leads to some kind of adverse social impacts, diminishing the social sustainability of the intervention, project or other form of action.

Research on the **justice dimension of the ET** has been called out as lacking (Sun et al., 2023). Potential realms of social inequality and thereby unsustainability of the ET are: Inequity in resource extraction (e.g. Roche et al. (2023)), investment, siting and financial gains of renewable energy generation of wind or solar energy (Bennett et al., 2023; Ghisellini et al., 2023), events such as blackouts due to changed grids and infrastructures, hitting in particular the less well-off and prepared (Capitanescu, 2023).

CC leads to multifaceted risks and also **CCA and disaster risk reduction lead to multitude of - direct and indirect - social impacts**. In the CCA literature, the vulnerability of social groups is an essential factor in the assessment of CCA social impacts (Filho et al., 2018; O'Brien et al., 2006). Progressing insufficient mitigation and adaptation to climate change policies lead to increasing inequality of human costs of climate heating, including social conflicts arising from i.a. extreme weather events, poor harvests and health inequalities (Lenton et al., 2023). As Imperiale and Vanclay (2023) suggest, the observation of social impacts in climate resilience, CA and CCA pursuits is difficult. Understanding the particular urban social impacts of CCA is crucial in the light of increased global levels of urbanisation.

2.6. Research gap and sub-research questions

The social dimension of urban densification has gained attention in academia and spatial planning. The same accounts for the social impacts of the ET and CCA. But the collection of the scientific stance on feedbacks and trade-offs on a multidimensional basis, at the interface of the three transitions, needs to be explored (Ahlfeldt & Pietrostefani, 2017). To prevent undesired **social impacts due to urban densification *and* climate action processes**, it is necessary to identify gaps and overlaps between science and practice in terms of the potential social impacts of **urban densification processes in times of *simultaneous* CA interventions**.

Due to the limited space in the urban built environment, I hypothesise that there are social impacts only arising from the simultaneous engagement in urban densification and CA. These social impacts originate from **interdependencies between the transitions**, see Figure 2.5. This is founded in the fact that these transitions compete with each other in terms of space and budgets, which could be monetary or in the form of environmental impacts. Additionally, the transitions create first and second order biophysical impacts on each other and lastly, on the global systems as depicted by Rockström et al. (2023).

I want to try to identify these interdependency themes in my analysis to assess the social impacts arising from them. Therefore, this project aims to compile the current knowledge comprehensively, to not only look at social impacts arising from densification, but, to look at them in times of simultaneous CA interventions. This may shed light on social impacts predominantly due to the arising interdependencies of the simultaneous development.

As shown by Berghauser Pont et al. (2021), comparing the impacts of urban densification stated in literature with the planning motivations of municipalities can reveal indications for urban planning and research alike. These are crucial to be observed in urban densification processes on municipal agendas. By comparing scholars' and urban policymakers's explicit and implicit mentioning of social impacts, knowledge gaps or overlaps on both sides may be identified to give indications to research and policy-makers working on urban densification in these times of CA.

Finally, such a profound knowledge is indispensable to follow principles of precaution, to limit urban inequalities and to prevent the propagation of vulnerabilities as these urban interventions proceed.

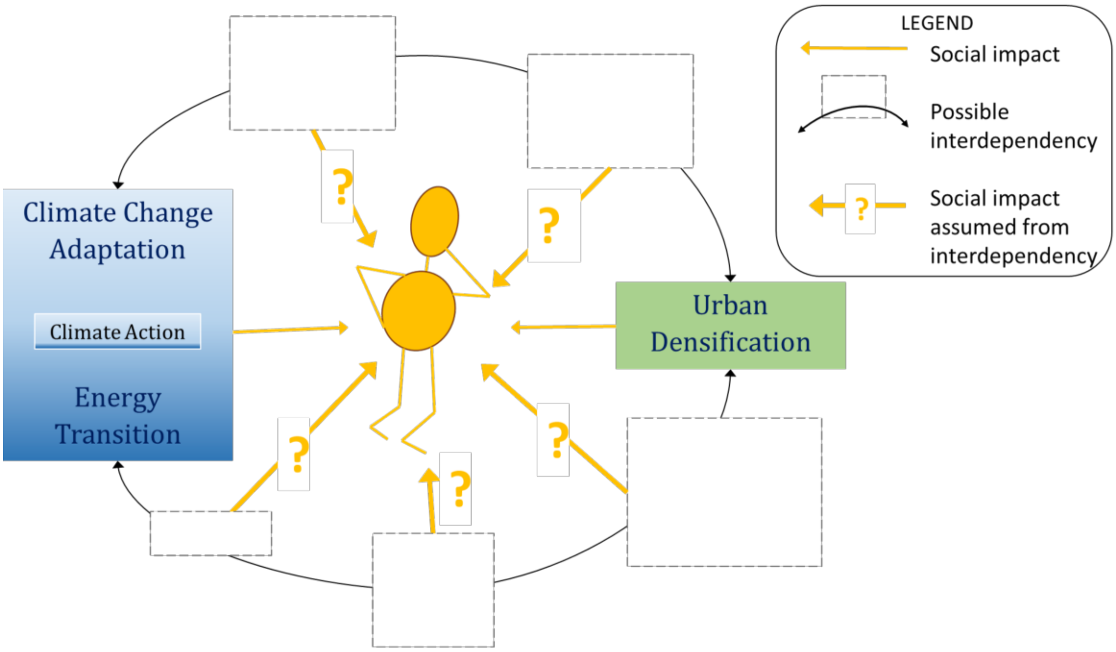


Figure 2.5: Hypothesis: Next to the direct social impacts of each transition (yellow arrows), interdependencies between densification, CCA and the ET (dashed boxes) create social impacts (yellow dashed arrows).

This said, **it is reasonable to ask the main research question** of this thesis:

Which social impacts arise from simultaneous urban densification and climate action in the form of climate change adaptation and the energy transition?

I accompany this main question with **four sub-research questions (SRQs)**:

1. Which social impacts arising from the interdependencies of simultaneous urban densification and climate action-related transitions are explicitly and implicitly mentioned in literature?
2. Which social impacts arising from the interdependencies of simultaneous urban densification and climate action-related transitions are perceived by policymakers?
3. How does the perception of urban policymakers differ from or overlap with social impacts mentioned in literature?
4. Which are the main contextual factors mentioned with regards to these social impacts and what are the implications for research and policymaking?

2.7. Research design

In the words of Joensuu et al. (2020), the urban built environment is a "technical, environmental and cultural system that is produced, used, managed and maintained by humans for humans, making it a topic the understanding of which calls for multidisciplinary knowledge" (p. 3). The IE lens is a suitable tool to investigate these questions.

The approach I chose is a qualitative mixed-methods approach. This parallel observation of two perspectives, shown in Figure 2.6, **an integrated mixed methods review synthesis**, (Guetterman & Fetters, 2018), constitutes (see Figure 2.7 in two pages):
Based on a comprehensive literature review, I create a knowledge base to answer SRQ 1. The answer to SRQ 2 is explored in a case study, at the hand of interviews that I conducted with urban policymakers in the urban development departments in the municipality of Amsterdam. By means of their replies I gained better insight into policymakers' perception of the social impacts and system connections.

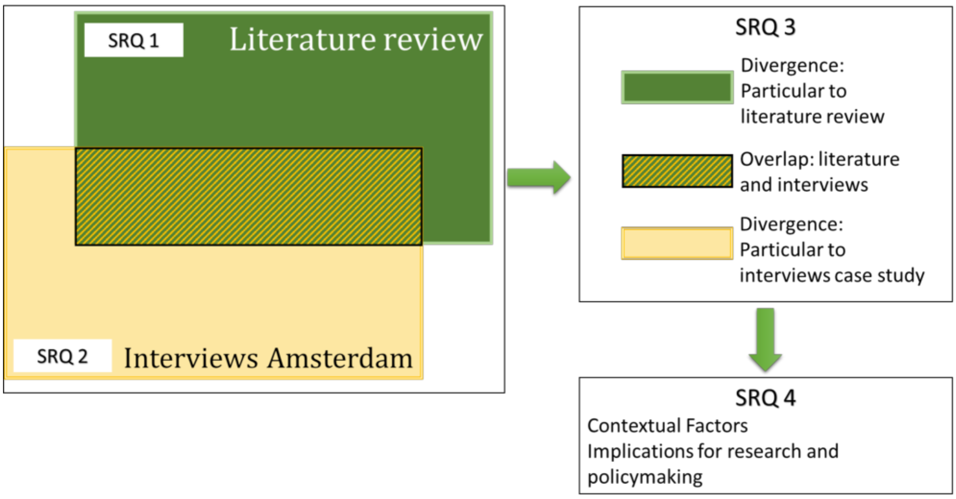


Figure 2.6: Outline how the SRQs will be answered by the observation of the 2 perspectives on the social impacts of urban densification in times of climate action.

Finally, a comparative thematic analysis enabled me to discern overlaps and divergences and contextual factors from the insights gained in SRQ 1 and SRQ 2 to answer SRQ 3 and SRQ 4.

2.7.1. Justification and limitations of the chosen design

The first method chosen is a **systematic, integrative literature review**. Such a review collects and synthesises previous works published on a topic in a structured manner (Rocco & Plakhotnik, 2009; Snyder, 2019; Torraco, 2016; Xiao & Watson, 2019). In this way, I conducted a synthesis of the insights collected to create a knowledge base, founded on the literature review items. This re-conceptualises and thereby widens the perspective on the relationships between densification, the CA transitions and their social impacts. As Xiao and Watson (2019) state, the goal of a [stand-alone] review is to "attempt to make sense of a body of literature through the aggregation, interpretation, explanation, or integration of existing research [...]" (p. 94).
This thesis therefore encounters the difficulty to describe and categorise social impacts of densification and CA transitions. This is achieved by making use of processes and experiences depicted in previous work of other scholars. Within the constraints of a master's thesis, it is justified to approach the research questions which such a strong reliance on other scholars' work, instead of other theory-building approaches such as grounded theory.
The second method, the conduction of **semi-structured integrative, exploratory interviews with urban policymakers** allows for the observation of the gap between research and practice in the context of the chosen case study. Thereby, the first part of the thesis is supplemented with an integrative, exploratory element (Whittemore & Knafl, 2005; Xiao & Watson, 2019). Semi-structured interviews are well-suited to the exploratory nature of SRQ 2. They provide manifold insight into stakeholder perceptions by allowing follow-up questions and probing of the interviewees (Adams, 2015).
This approach looks at studies observing bio-physical and technological changes and their consequent social impacts as well as the perception of these changes and their social impact of actors from the field of governance. This combined method not allows for the identification of hot-spots for further research (Rocco & Plakhotnik, 2009; Torraco, 2016), but is also substantial to the field of IE.

I agree with Vanclay (2002)'s calls for caution. To conceptualise social impacts without community input, i.e. without involvement of the affected public and merely basing the assessment on expert judgement leaves strong blind spots. Not at last, is the desirability of projects or their alternatives or the weighting of gravity of social impacts only to be retrieved when the community affected is heard.
During the course of the thesis project, my focus was set on trying to grasp potential social impacts as comprehensively as possible, founded on the reports of a multitude of scientific research. I make use of the intersectionality understanding and system thinking approaches and I aim at providing a holistic image of the social impacts of urban densification and CA transitions. However, social consequences

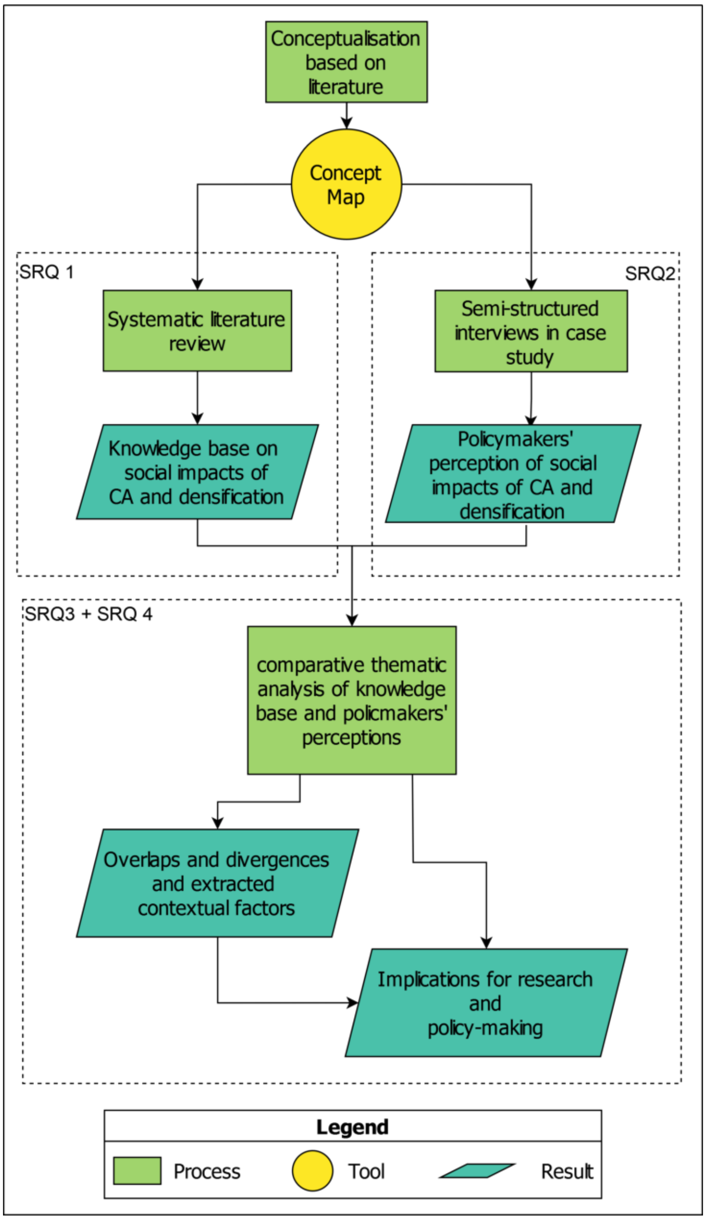


Figure 2.7: Research Design of the thesis: mixed methods design of a systemic literature review and semi-structured interviews in a case study. The results of the two methods are a knowledge base of social impacts and the perception of social impacts by policymakers. They will be compared in a thematic analysis. Lastly, the main contextual factors overlaps and divergences will be discerned to draw conclusions for research and urban planning policymaking.

pointed out are founded on my understanding of social processes and thereby subjective. They are also the result of my positionality, bias and background as well as the authors' and interviewees' bias and positionality. Nonetheless, I aim at reflecting on these drawbacks in the comparative analysis (Braun & Clarke, 2006, p. 80) of my data sets and am always open for exchange in the matters discussed.

2.7.2. Scope of this thesis: urban boundaries

My scope focuses on the relationships between densification and other urban transitions on a city level, including metropolitan areas. In some cases, the assessment will also go beyond the city limits where data sources highlight impacts outside these boundaries which are too substantial and impacting to be left out of the discussion, either in the social or environmental dimension.

Chapter 3

The Social Dimension: Background Literature

In this chapter I delve deeper into urban social impact relationships. First, in Section 3.1, I will provide a rough overview on intersectionality and urban inequalities which affect the recipients of social impacts. Second, I explore the seven SIs of Vanclay's framework at the hand of literature. This is illustrated visually in Section 3.2 and provided in full in appendix A.5. I considered literature focusing on impact interactions in the urban space. These later-on determined my reasoning in the data analysis.

3.1. Intersectionality and urban inequality understanding

As social identities are complex and dynamically shaped by contexts, traits and experiences, scholars have argued that the vulnerability of (urban) residents (Kuran et al., 2020; Versey, 2021) to threats such as climate change are **subject to intersectionality**. In this sense, how much an individual in its context is affected by a process, will depend on the individual's intersectional traits. Often, such impacts can lead to a **perpetuation of inequality**. For instance, might a meteorological disaster such as a flood or heat wave affect health, income, community and gender categories to varying degrees through loss of harvest, income, relocation and gendered behaviour or (im-)mobility patterns (Ergas et al., 2021; Harlan, Sharon L et al., 2015; Nagel, 2015)

Along this understanding, city elements and relationships affect human residents in different ways. Social and environmental impacts underlie intersectional mechanisms, "[...] considering interlocking systems of oppression, such as - but not limited to - race, gender, class, sexuality, ethnicity, nationality, indigeneity, ability, religion, species, scale and rural/urban as well as Global South/North divides" (Ergas et al., 2021, p. 15). This means that individuals who identify with distinct traits or (assigned) roles will be affected in distinct ways and magnitudes. The intersectionality understanding as per scholar Crenshaw (1989, 1990) has been applied not only to **environmental, climate and social justice issues** (Ergas et al., 2021; Malin & Ryder, 2018; Ryder, 2017), or **climate justice** (Kaijser & Kronsell, 2014), but also to **urban planning and other forms of spatial planning** (for health equity see Williams et al. (2023), for mobility Cundill et al. (2021), for CCA planning Osborne (2015)).

3.2. Literature review on social impacts

This section elaborates on the applied conceptualisation of each of Vanclay (2002)'s seven SIs (consider again to Appendix A.1 for the full list). I allocated the full-text version of the literature review to Appendix A.5, where each subsection includes the literature contributing to the reasoning of social impact occurrence in the analysis in this project. Figure 3.1 in the main text of this chapter summarises the main points per SI that the literature I consulted elaborates on.

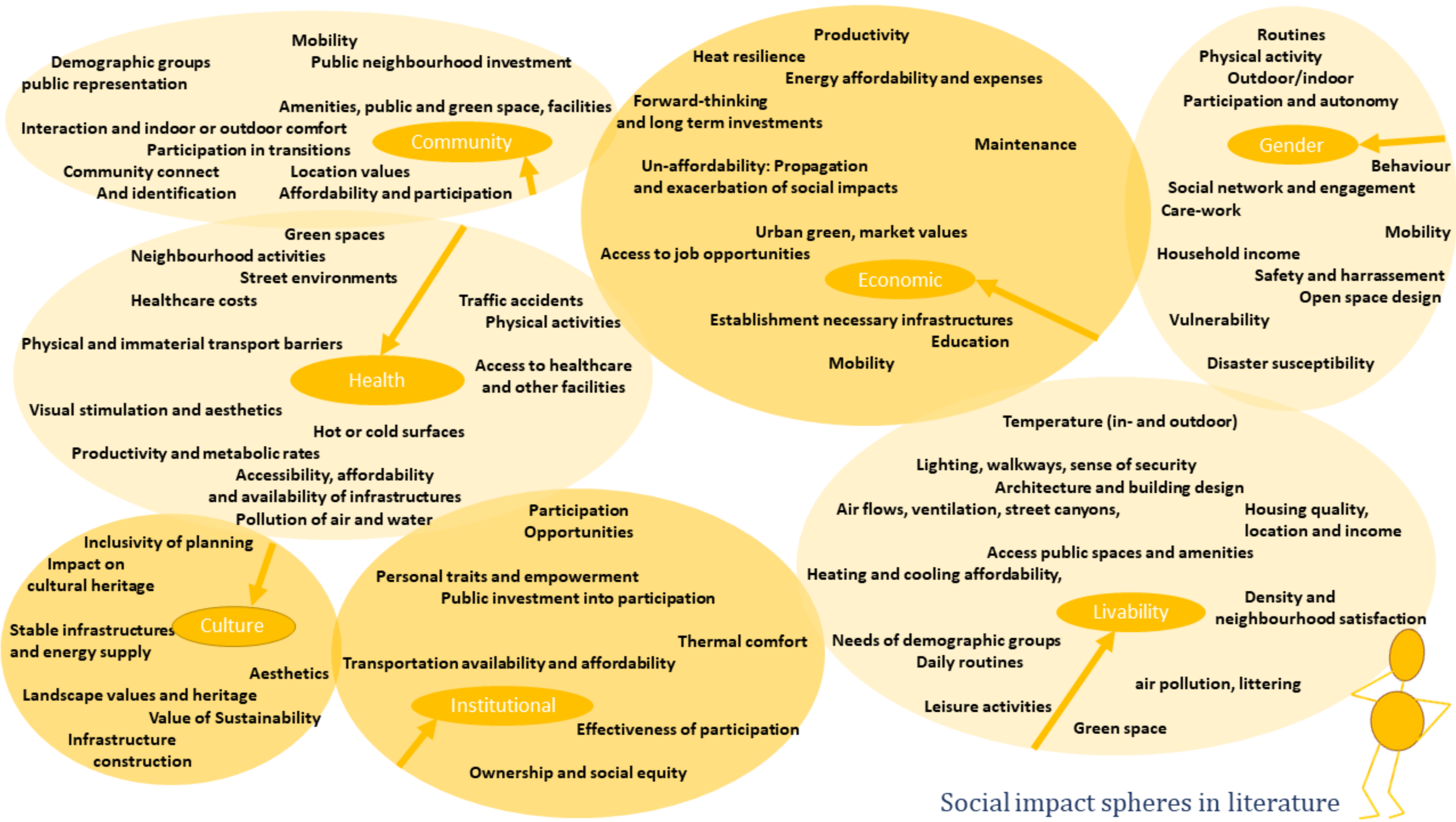


Figure 3.1: Social impact spheres with conceptualisation of Vanclay (2002)'s SIs as applied in this thesis. Each word bubble represents the main issues discussed in the literature reviewed and described in Appendix A.5.

Chapter 4

Methods

In this chapter I provide an overview of my methods. Starting by revisiting the conceptualisation of the previous chapters in Section 4.1, I present the first data collection method, the literature review, in Section 4.2. In Section 4.3 I describe the case study selection and then elaborate on the second data collection method, the interviews, in Sections 4.3.2 and 4.3.3. The analysis of my collected data is described in Section 4.4. I first describe the identification of the interdependencies between densification and the CA transitions in section 4.4.1 and state the terminology that I applied in Section 4.4.3. Then I explain the codebook that I used (consult Appendix B.6). Lastly, I explain how I synthesised my results to discern overlaps and divergences and to draw conclusions in section 4.4.4.

4.1. Desk research and conceptual map

Desk research on densification, the CA transitions and the categorisation of social impacts stood at the opening of this study, see previous Chapters 2 and 3. Founded on this knowledge, a three-dimensional (3D) conceptual map (CM), Figure 4.1, was designed.

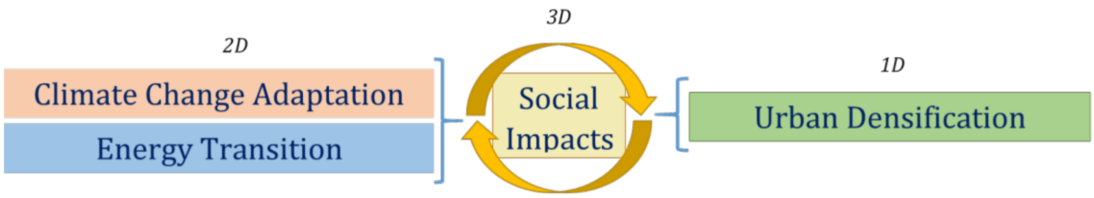


Figure 4.1: Three-dimensional conceptual map based on the conceptualisation in the previous chapters. The 1st dimension (1D) is urban densification. The second dimension (2D) is CA and the two transitions embedded therein. The third dimension (3D) are the social impacts created.

This map served as a baseline in the research (Rocco & Plakhotnik, 2009; Torraco, 2005) and included:

- 1st dimension (1D): the densification variants and features observed in this thesis, see Figure 2.2,
- 2nd dimension (2D): the two CA transitions in the focus of this study, Figure 2.3 and Figure 2.4, and
- 3rd dimension (3D): the social impact categories and their individual social impacts, Figure 4.6 as an example for the SI health, as defined by (Vanclay, 2002), explored in Chapter 3 and listed in Appendix A.1.

4.2. Literature review: data collection

The review goal was to find answers to SRQ 1 and to create a knowledge base on the social impacts arising from densification and simultaneous CA. This provided input for SRQ 3. Figure 4.2 displays an overview of the data collection in the literature review.

4.2.1. Search strategy and created data set

The setup of the literature review methodology was guided by the step-by-step guidelines of Xiao and Watson (2019), Torraco (2005), Javidroozi et al. (2023) and Moher et al. (2010). First, general decisions

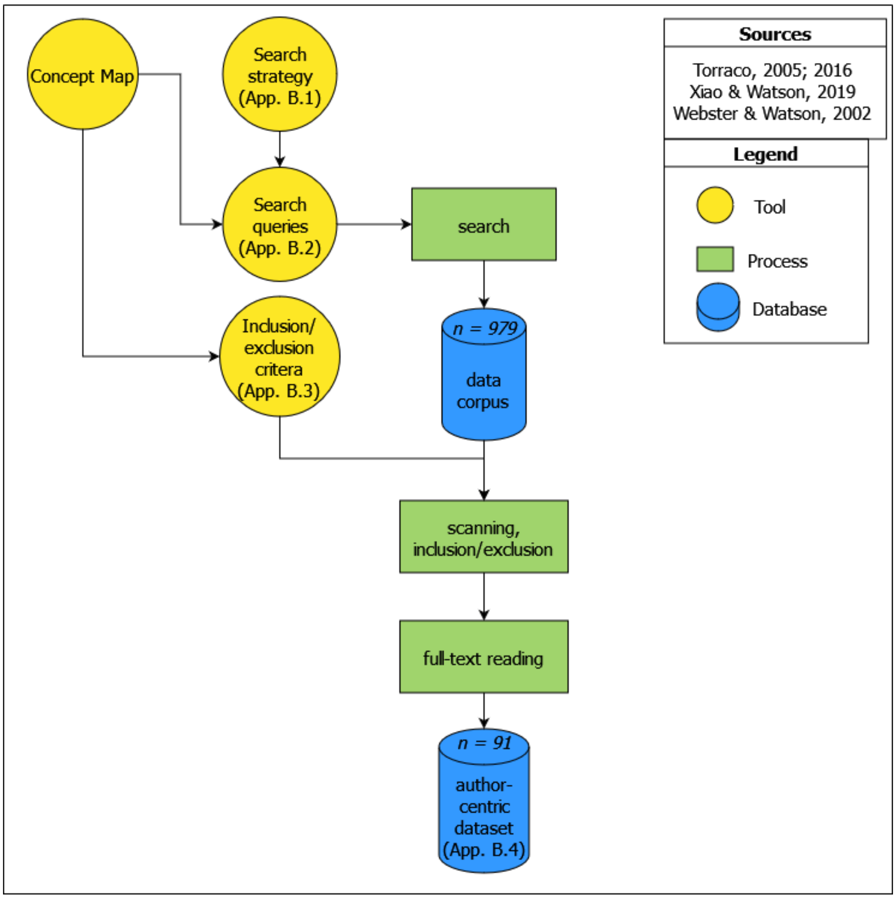


Figure 4.2: Data collection literature review: Based on the conceptualisation of the transitions and social impacts, the search was conducted. I defined the search queries on the basis of the search strategy. The generated data corpus (n = 979) was scanned for relevant items, making use of the inclusion and exclusion criteria. I based the criteria on the CM. The reading of the full-text items brought me to an author-centric data set (n = 91, Sources: Torraco, 2005; 2016, Xiao and Watson, 2019; Webster and Watson, 2002).

about the **search strategy** were taken. The search strategy that guided the literature review is included in Appendix B.1. The search strategy differentiated between decisions and processes. The search was conducted in the abstract, title and keyword fields of the databases SCOPUS and Web of Science. There was no publication date limitation set. In the next phase the search was conducted and works collected and stored (n = 979). The generated data corpus was scanned for relevant items, making use of the inclusion and exclusion criteria. I based the relevancy decisions on the CM. The reading of the full-text items brought me to an author-centric data set (n = 91). This followed the steps of 1) identification, 2) screening, 3) eligibility and 4) inclusion.

4.2.2. Literature review per search theme

The **search strings** were established based on the CM. These had to be kept broad to not exclude studies whose main purpose might not have been to investigate social impacts as such, but rather, mentioned them as a side effect. I created a spreadsheet with search strings and the number of the retrieved results for the ET and CCA respectively, see Appendix B.2. This formed the data corpus as per Braun and Clarke (2006).

After they had been collected in SCOPUS, duplicates were removed and the abstracts of the search results scanned for applicability to the search goal. For the articles on the themes of mobility and heating and cooling in the ET a .ris-file with the search results exported. I imported this file to ASReview.nl. This open source software, developed at Utrecht University, is based on an active learning algorithm which scans the abstracts of a provided list of written works (ASReview LAB developers, 2023). At the start of a new project, the reviewer trains the algorithm by labelling irrelevant and relevant papers. In line with the training set, the provided titles are sorted by the algorithm as per their expected relevance for the human reviewer. After saturation of the search project, i.e. the decrease in relevant paper frequency, the review could be stopped. This enabled me as the reviewer to extract an excel-file with the sorted articles (based on the heating and cooling and mobility search queries), which I then scanned and read when deemed relevant to the RQ. The project training information and sorted data can be requested.

The **inclusion and exclusion criteria** were organically derived from the CM, the project's scope and SRQ's. Excluded search results were items that did not adhere to research in urban or built environment systems. For instance, several results were not appended to the list as they did not refer to urban, but other forms of densities (e.g. fluids). Similar field in-applicability occurred for searches of precipitation. Here, results for sediment precipitation were excluded. Almost all conference proceedings were excluded as well, with the exception of an item that was identified as such later-on. Further, the search was based on search queries and items in the English language, with one exception. The inclusion and exclusion criteria are included in Appendix B.3.

The remaining articles were read in full and the author-centric data-set established, see Appendix B.4, (Webster & Watson, 2002). The data collected from the literature review were general information about the publication of the item, the method, the authors' conclusions and implications for the research goals as most important to name here ans amongst others.

4.2.3. Review outcome overview

The literature review focusing on **papers on the ET in the context of densification** generated a final amount of 41 results. Many papers were also collected in the complementary review, via snowballing of references, insights and authors. The majority of papers was collected for the search strings of mobility and heating and cooling. Low numbers of papers were collected in the spheres of energy infrastructure (without reference to production and use), as well as food production or energy availability.

The search for **papers on the intersection of densification and the CCA** could be based on prior knowledge collected during the literature review on the ET. This was particularly the case for the CCA element of thermal comfort. Overall, 47 papers were collected and added to the CCA catalogue.

Three papers were added which are not added to one of the two transitions in particular. These were collected in author snowballing and deemed relevant as for their particular knowledge on densification implications on public health.

4.3. Case study

4.3.1. Case study selection: The city of Amsterdam

The current municipal government of Amsterdam subsumed their council period under the guiding principles of equal opportunities, sustainable future, responsible growth and cooperation. This is guided by the motto of "a solidary city, with opportunities for everyone" in the current coalition agreement ((PvdA) Moorman et al., 2022).

The selection of Amsterdam as a case study was due to several reasons. First, the termed housing crisis is pushing the Dutch capital to massively create housing units. The idea to conduct this project was born at the background of the current drafting of a densification strategy for housing development (Gemeente Amsterdam, 2023k). Secondly, the city is at the forefront of climate and resource aware governance: Amsterdam took on the challenging goal of restricting its development to the city's boundaries, while pursuing the ET, CCA, an increase in the biodiversity in the urban space and a circular economy.

Lastly, readers can be pointed towards Churchman (1999). The author depicted the Dutch urban planning strategies and reviewed Dutch works from as early as 1988, focusing on urban densification. With the intention to form the Dutch Randstad area, separated from the area of the so-called "Green Heart" (*groene hart*), aiming at a reduction of urban sprawl and agglomeration of urban environments. Therefore, Amsterdam poses an interesting and highly knowledgeable case study.

4.3.2. TU Delft human research ethics approval procedure

As the research drew from human individuals' input, such as opinions, perceptions, interests, knowledge, understanding etc., it underlay the TU Delft Human Research Ethics (TU Delft, 2023). Prior to the organisation of the interviews, I applied for the approval of the research design at the Human Research

Ethics Committee of TU Delft. I underwent a risk planning session after the kick-off of the project. This session is intended to identify direct or indirect risks arising from the participation in the research itself and its publication and to draft a risk communication concept. The risks were communicated in the **form of informed consent (ICF)**, Appendix C.1. The ICF was sent out to the participants prior to the interviews to inform the participants about the general purpose of the research and their role as participants in the interviews. The ICF is the essential legal ground for the participants' consent to their participation in the interviews and their understanding of the possibility of risk occurrence resulting from the interviews and the use of their content. This procedure was also part of the Data Management Plan (DMP), designed in the risk planning session. The collected data were stored, anonymised, published and deleted in line with the set up data management plan (DMP). Finally, the DMP and the ICF template were submitted to the Human Research Ethics Committee (HREC) of the TU Delft for approval. This procedure was also part of the research process to improve the adherence to standard research ethics in qualitative research including human individuals (Knott et al., 2022).

4.3.3. Interviews: data collection

The organisation of the interviews followed the points in the **interview protocol** provided in Appendix C.2, an overview is given in Figure 4.3.

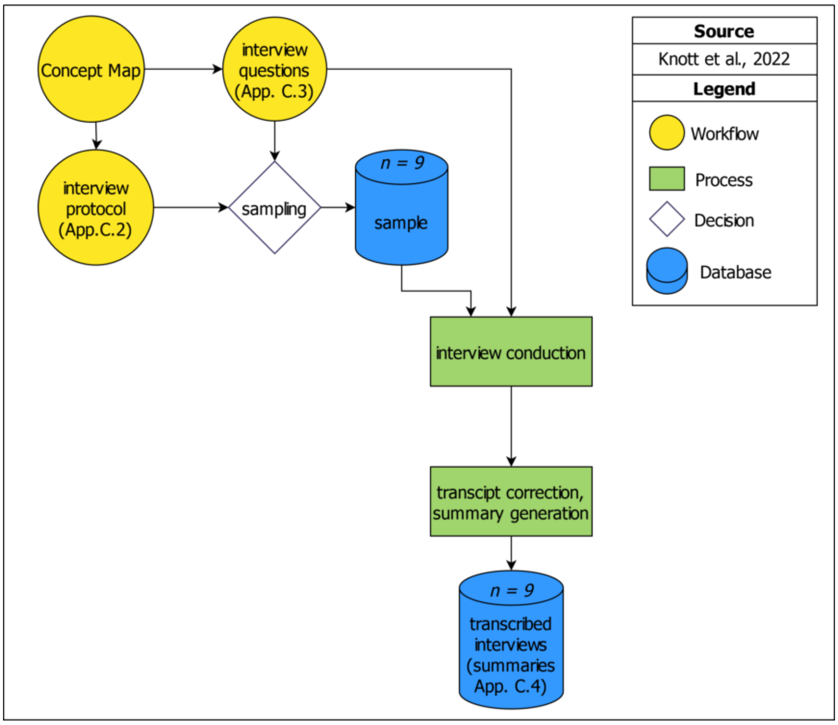


Figure 4.3: Interview data collection: I based the interview protocol and the questions on the preparatory literature review and the conceptualisation. After deciding on a suitable sample of 9 interviewees, I conducted the interviews and corrected as well as summarised the transcripts. This lead to a database of transcribed interviews (n=9, Source: Knott et al., 2022).

The sampling of interviewees was founded on a non-random sample, which was not aimed at obtaining randomized and generalizable opinions of a large population, but to collect qualitative insight into very specific evaluation of the relationships associated with the research objective in urban development departments (Bhattacherjee, 2012). A contact with the municipality was established and supported the search for interview participants, as well as an internet and LinkedIn in search for members of the CCA and ET planning departments in Amsterdam. Moreover, one of the interviewees was named by another participant as a helpful source for the purpose of the project. An overview of the sample professional focus is given in Table 4.1.

Table 4.1: Case study sample of interview participants and their professional focus.

Participant	Densification	ET	CCA	Social	Sustainability
Interviewee D	x				
Interviewee E	x		x		
Interviewee F		x			
Interviewee G			x		
Interviewee H					x
Interviewee I		x			
Interviewee J				x	
Interviewee K				x	
Interviewee L					x

Within the semi-structured interview setup, a **catalogue of guiding questions** was assembled, see Appendix C.3. Here, forward-thinking was necessary to cover the relevant points of interest in the interviews (McIntosh & Morse, 2015). It was aimed at gathering sufficient insight in one interview per participant. For this reason, guiding questions were developed to cover the elements of the CM, Figure 4.1. They were structured into 7 blocks, including intended duration times to spent on them as a guidance for the interviewees: formalities, general, the ET and the CCA as well as questions on the biodiversity transition and circular economy and a closing block. The biodiversity and circular economy transitions were later discarded off from the main focus of the thesis project. The interview sections still provided insightful information for the discussion of the results.
Each of the interview participants received the ICF, some general information about the project and the questions catalogue prior to the interview to enable them to inquire about any unclear points on the topic or the project procedure. The interviews were conducted in a digital video meeting.
The interviews started with a general opening statement, summarising the research purpose and establishing that the consent to the participation in the interview had been given. The remainder of the interview followed the template of the semi-structured interview questions. Where reasonable and necessary, adjustments of the questions and duration were made corresponding to the interviewee's experience and time available for the interview.
Immediately after the interview, the author completed the short-hand notes made during the meeting including the main conclusions taken from the interview in a half to one page memo. This memo included a remark on how the author perceived the interview situation and atmosphere. This allowed for a later recollection and reflection on the interview situation where necessary (Knott et al., 2022).

4.3.4. Interviews: data treatment and follow-up

The interview transcripts that were generated within the MS Teams software were corrected were the automatic transcript was wrong. In line with the DMP, the HREC application and most importantly in line with the agreement made with the interview participants, a **summary was drafted** for each of the interviews and send to the respective interviewee. This summary, see Appendix C.4 as .pdf file in the supplementary information, included my understanding of the interview sections in quotations and paraphrases. These were the sections that I wanted to be able to include in my thesis. I took this step to ensure a correct representation of the participant's statements (Bhattacherjee, 2012).

4.4. Analysis and synthesis of collected data

For both methods of data collection, the same analysis method was chosen: a **thematic analysis** as pre-condition for the synthesis. Figure 4.4 displays an overview of the analysis.

The thematic approach of Braun and Clarke (2006) provides a flexible analysis tool originated from the field of qualitative psychology. The **explicitly stated (in literature and in the interviews) and derived (i.e. reasoned by the author)** first and higher-order social impacts had to be identified. For this purpose, I first established a **codebook** based on the CM, see Figure 4.5 and the full codebook in Appendix B.6 (Bhattacherjee, 2012; Knott et al., 2022; McIntosh & Morse, 2015; Schmidt, 2004; Xiao & Watson, 2019). The labels were grouped into SI, CA, densification and additional report labels. The codes for the CA transitions was based on the conceptualisation summarised in Figure 2.3 and Figure 2.4. The codes related to urban densification however did not define variants of features. In both data sets these

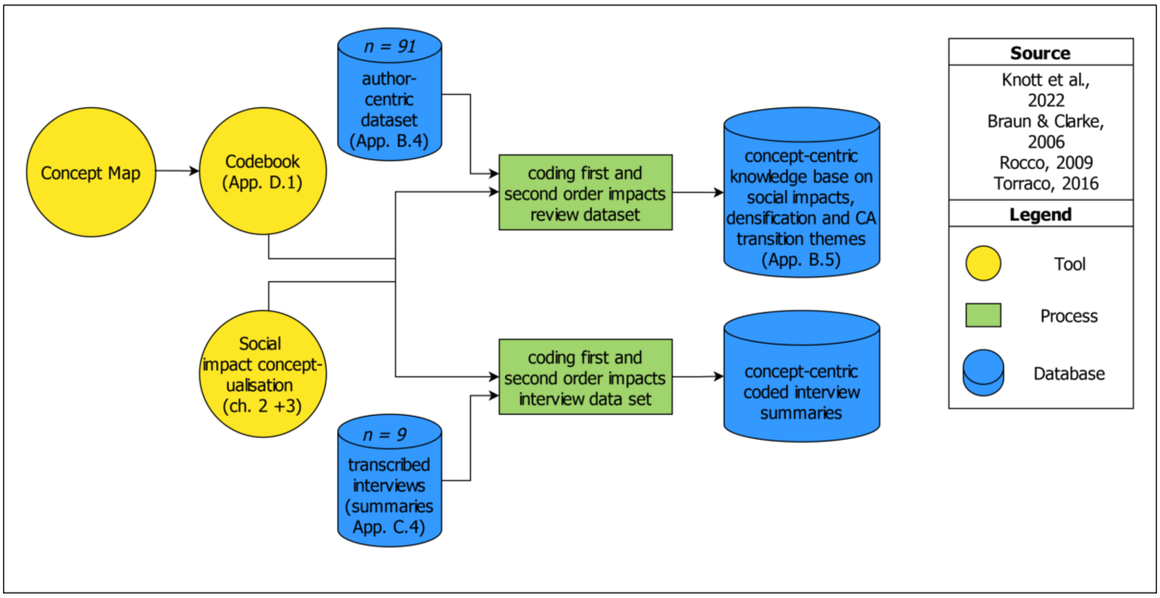


Figure 4.4: Analysis of the two data sets: A codebook was developed based on Chapter 2. I coded the author-centric literature review dataset as well as the interview data set. This resulted in the coded results, the concept-centric knowledge base, and the concept-centric interview summaries (Sources: Knott et al., 2022; Braun and Clarke, 2006; Rocco, 2009; Torraco, 2016).

were often not specifically named by the sources. Instead, I inductively looked at densification attractions, costs, enablers, strategies and population density and accompanying policies/tools. Additional report codes that I added deductively included statistical information (such as "region", "research field" or "methods" of the literature review items) or recurring phenomena (such as "ownership", "knowledge silos" or "urban inequality") which gave insight into the diversity of the collected data and/or were used in the discussion of the results.
Figure 4.6 shows the multitude of the individual social impacts at the example of the SI health. For the remaining SIs, refer to Appendix A.

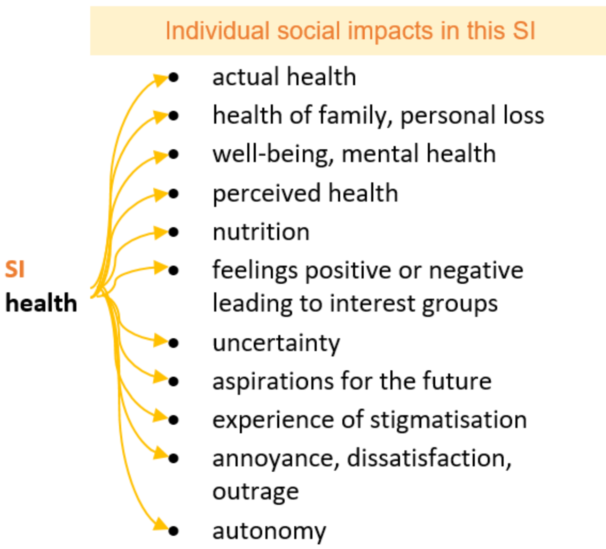


Figure 4.6: Example of the individual social impacts comprised in SI "health".

CODE GROUPS	CATEGORY CODES	LEADING TO NUMBER OF CODES
SOCIAL IMPACT CATEGORIES (SIS)	Community (indicative family and community impacts)	10
	Culture (Indicative cultural impacts)	7
	Economic relations (indicative economic impacts and material well-being impacts)	14
	Gender (indicative gender relations impacts)	9
	Health (indicative health and social well-being impacts)	13
	Institutional (indicative institutional, legal, political and equity impacts)	8
	Liveability (indicative quality of the living environment impacts)	13
DENSIFICATION CONTEXTUAL INFORMATION	Densification	6
ENERGY TRANSITION (ET)	Production	2
	Use	2
	Energy infrastructure	2
CLIMATE CHANGE ADAPTATION (CCA)	management	3
	thermal comfort	8
	water	6
OTHER AND DEDUCTIVE	Scale	10
	Amsterdam	3
	Region/Country	55
	of which case region	16
	Countries	31
	of which case countries	9
	Field	31
	Method	41
	Circular Economy (CE)	3
	Biodiversity increase	3
	Deductive codes	26
TOTAL	25	331

Figure 4.5: Overview of the codebook applied, the five code groups based on the conceptualisation included 25 category codes and lead to 331 individual codes. Complete codebook in Appendix B.6.

4.4.1. Interdependencies of densification, the ET and CCA

In the analysis of the data, I could discern **five themes of interdependencies** between densification, the ET and CCA: 1) the UHIE, heat and drought, 2) WATER: flood and rain, 3) mobility, 4) heating and cooling, and 5) energy and electricity grid and sources, see Figure 4.7. These emerged as recurring patterns in the data, themes that lay at the interface of densification and CA.

An example: Densification with the aim of housing creation and provision of additional facilities, might be conducted through, for instance, the addition of floors on top of an existing building. Logically, this could affect the experience of the UHIE, by changing air corridors or increasing shading, but also the volume of heat-absorbent or reflecting building materials. What is more, its added amenities as well as residential units might affect the electric and thermal energy systems through direct usage of electric energy for appliances but also via heating and cooling. A shift towards an electric mobility system pursued at the same time, and now for an increased number of residents in the neighbourhood will also require additional grid and storage capacities. Lastly, if many housing units are added and construction is taking place below ground or on ground level this affects the hydrological system in place. Not only will the use of potable water change due to the consumption patterns of residents, but the building will impact underground water flows, the sewage and drainage systems, especially during strong rainfall events, or after dry seasons. Vice versa, these will affect the building and its residents.

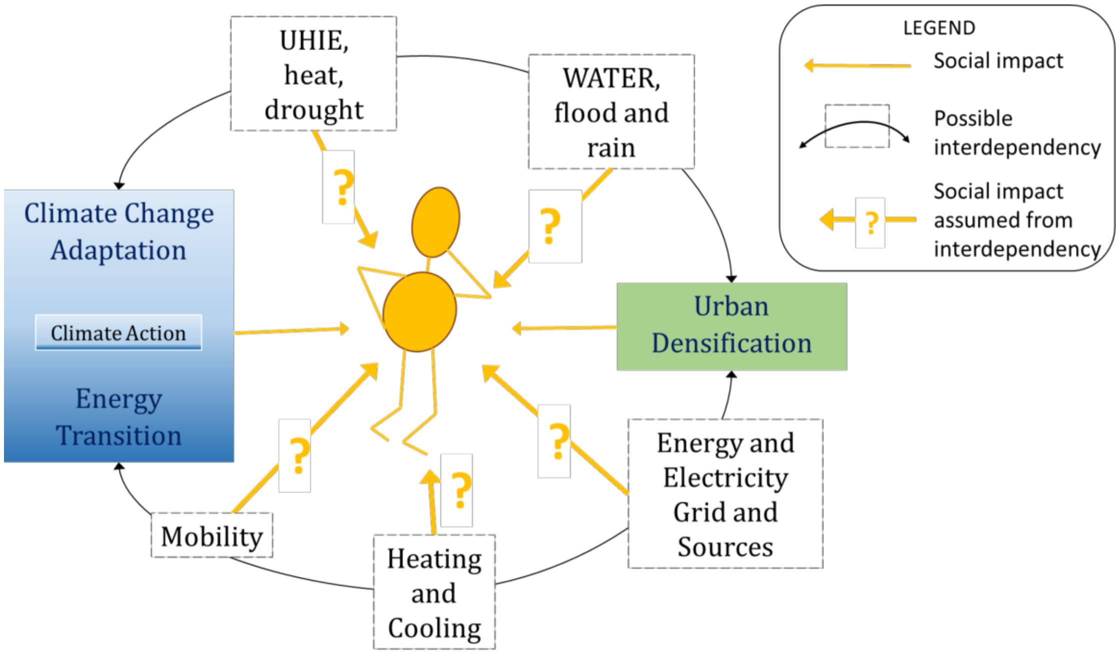


Figure 4.7: Next to the direct social impacts of each transition (yellow arrows), I identified interdependency themes between densification, CCA and the ET (dashed boxes) creating new social impacts (yellow dashed arrows).

Table 4.2 shows the codes that were assigned to the interdependencies. The mobility and heating and cooling themes only contain one label with the equivalent name respectively.
I conducted the coding in two rounds to limit overlooking or double-counting of SI reported in the data items. As this included reasoning, i.e. my interpretation, the coding drew largely from the conceptualisation and understanding in Chapter 2 and Chapter 3.

Table 4.2: CA labels organised into the five interdependency themes. Mobility and heating and cooling themes only comprise one equivalent label respectively.

electricity and energy sources and grid	heating and cooling	mobility	UHIE, heat, drought	WATER, flood and rain
energy grid	heating and cooling	mobility	air corridors	drainage
energy sources and generation			evapotrans-piration	dykes
energy storage			indoor temperature	fluvial
			outdoor temperature	grachten
			shading	irrigation
			solar radiation	potable water
			UHIE	rainwater collection
			ventilation	

The steps described above resulted in:

1. the concept-centric knowledge base excel workbook, see Appendix B.5 on social impacts of densification and CA transitions in response to SRQ 1, and
2. the concept-centric coded interview summaries as database in response to SRQ 2.

4.4.2. Regions and countries chosen for comparability

Moreover, to test the knowledge base at a case, I applied the findings from the literature review to the case study of Amsterdam: In parallel to the complete literature review data set and the interviews, I also extracted the main impacts from the literature review data set reduced to a region that was chosen to be comparable to the region of Amsterdam and the Netherlands, the "AMS-region". The list below includes the regions and countries within that were chosen due to geography, climate and common policy.

- Austria
- Central Europe
- Denmark
- Europe (city comparisons in three studies)
- Finland
- Germany
- global
- Ireland
- no region
- Northern Europe
- Norway
- Switzerland
- The Netherlands
- The UK
- Western Europe

This reduction tested the impact of geography and policy on the perception of social impacts in the literature and thereby the generalisability of the generated knowledge base to other cases.

4.4.3. Revisiting the analysis terminology

Concluding this section, I want to repeat the terminology I applied in my analysis.
"SI" refers to the seven social impact categories of Vanclay (2002). These comprise individual social impacts, the impacts that are experienced by human individuals. I conducted the coding on this level and could then compile and generate results on both levels, the SI and individual social impact level.
I distinguished between stated and reasoned impacts: Stated impacts were explicitly mentioned by authors or interview participants. Were I discerned impacts based on my conceptualisation and understanding as implicitly embedded in one of the two data sets, I speak of reasoned impacts. These, I therefore identified in addition to the stated impacts.
Finally, I identified five themes as interdependencies between densification, the ET and CCA. In the following chapters I refer to them either as "interdependencies", "interdependency themes" or simply, "themes".

4.4.4. Synthesis

In line with Webster and Watson (2002), the input knowledge for a synthesis may come from "theoretical explanations for "why", past empirical findings, and practice or experience" (p. xix). The synthesis of the data collected in my mixed-methods approach drew from past empirical findings, i.e. the literature assessed for a deeper understanding of the SI in the urban sphere, in Chapter 3. The steps of the synthesis are shown in Figure 4.8.

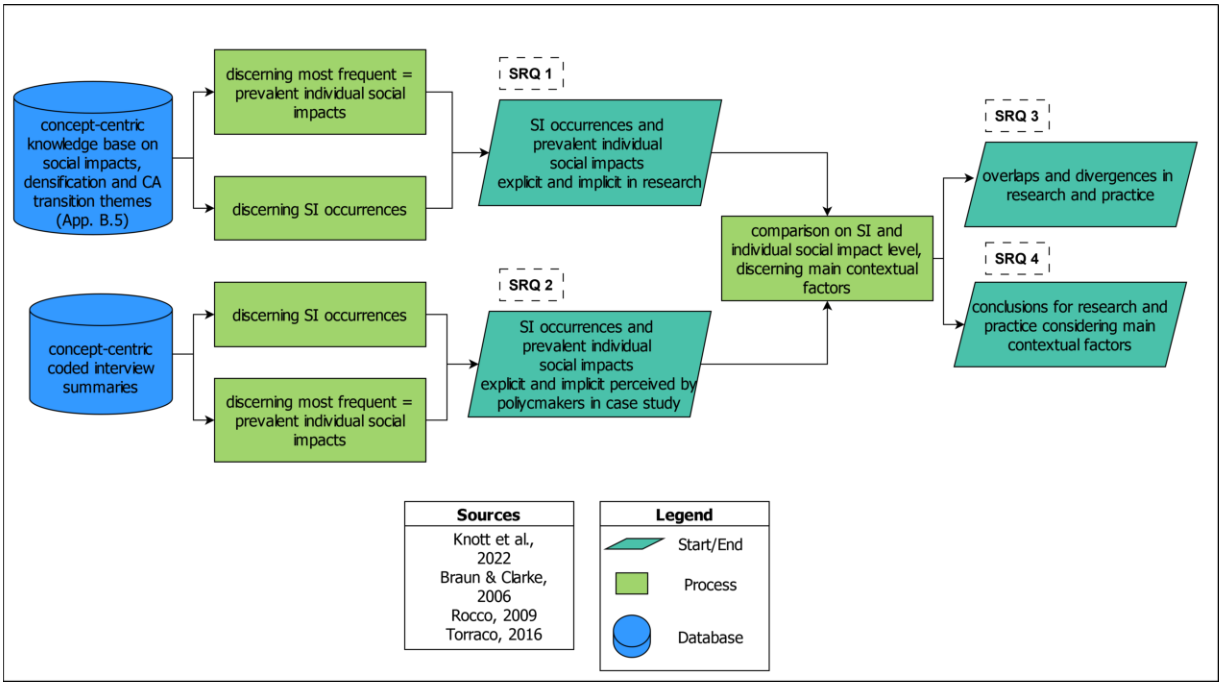


Figure 4.8: Concluding analysis of divergence and overlaps between research and policymaking practice. Comparison of prevalent individual social impacts in the themes and SI-code occurrences (Sources: Knott et al., 2022; Braun and Clarke, 2006; Rocco, 2009; Torraco, 2016).

I extracted the SI code occurrences and the co-occurrences between social impacts and the interdependency codes. I could rank the SI in the two data sets and discern the most prevalent social impacts for both data sets in the five themes. Additionally, these results were created for the AMS-region. These results were compared against each other to discern overlaps and divergences in terms of occurrence statistics and main contextual factors in each of the themes. Hereby, SRQ 3 could be answered. Lastly, to answer SRQ 4, the observation of the results and responses to SRQ 1-3 and at the light of the main contextual factors, conclusions for policymaking and research were drawn.

Chapter 5

Literature Review: Results

The results from the systematic literature review are presented in this chapter. You find an overview of the literature items in Section 5.1. This allows to better comprehend the results in the later analysis and to give more substantiated recommendations for further research. The result of the literature review, the knowledge base of stated and reasoned impacts is introduced in Section 5.2. For formatting reasons, the knowledge base is included as supplementary information as excel file in Appendix B.5. Lastly, in Section 5.3 I show the main statistics for the social impacts explicitly and implicitly mentioned in the literature review data set. I do this on the level of the SI, see 5.3, where I also show the results of a reduction of the literature review to the items in a region approximating the case study, the AMS-region. I close with an overview of the individual social impacts that are most prevalent in the five interdependency themes, see 5.4.

5.1. Literature items overview

This section presents the general statistics of the literature review. The list of articles can be obtained from the supplementary information in the Appendix B.4 excel workbook "author-centric LitRev data set".

Out of the total 91 items added to the literature review, 58 were published in the five year time span of 2019-2023. For the years 2012 to 2018, I assessed 3 to 4 items per publication year with the exception of seven items assessed that were published in 2016, see Figure 5.1.

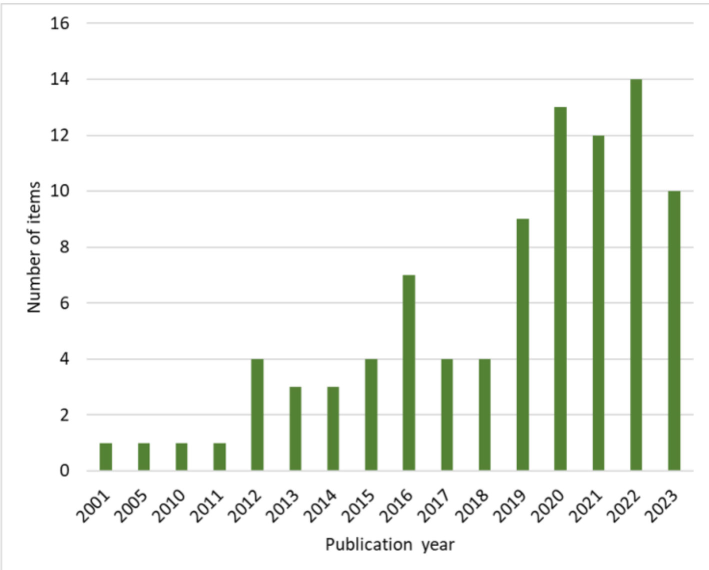


Figure 5.1: Overview of the publication years of the 91 items of the literature review. 58 papers were published between 2019 and 2023.

The literature review data set showed clearly that the publications per year increased steadily. After the number of published items jumped in 2012 and 2016, publication took off after 2019 and 2020. Considering the publication process length from the onset of a research project to the final publication in a journal, the strong increase in CC related topics in the years after 2010 and after the "Paris Agreement of the COP 2015, the Conference of the Parties of the United Nations Framework Convention on Climate Change (UNFCCC), might be one of the reasons for this increase. The publications related to a search on "CCA" in SCOPUS show a similar pattern. The number of published items in relation to "ET" also show a steady growth, even though in this field, publications started to increase in numbers earlier, leading to a more steady upwards curve.
The search was conducted in the period 08-05-2023 to 20-07-2023. Individual papers were added until 10-08-2023. The data set was comprised of 86 journal articles, 3 conference papers and 2 book sections. The most prevalent journals were Science of the Total Environment, Sustainable Cities and Society and Urban Climate with five respective publications. Energy Policy as well as Sustainability (Switzerland) each counted four items.
17 documents in the analysis observed data from Central Europe, thereby being the region with the highest document count. Northern America was divided into sub-regions, that in sum amounted to 11 studies. 9 studies were conducted in the Mediterranean and Western Europe, respectively. 8 studies used data from Northern Europe. These and the remainder of regions of study are shown in Figure 5.2.

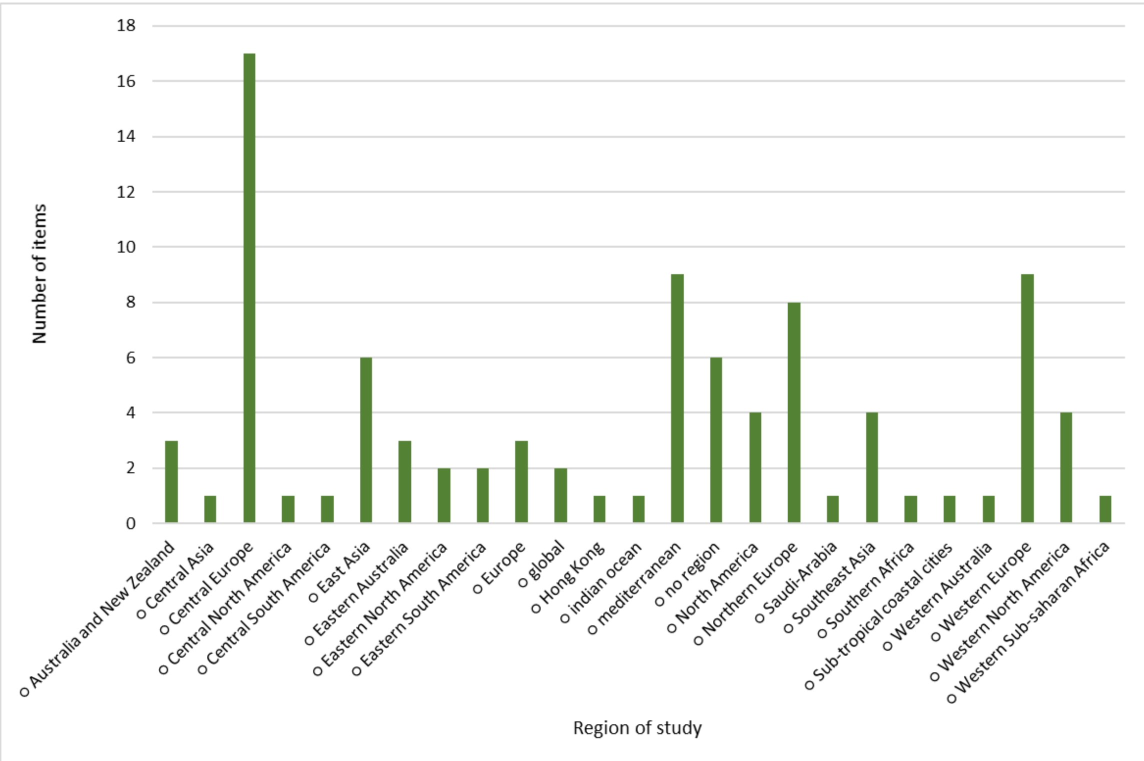


Figure 5.2: Overview of the regions of study of the 91 items of the literature review. "Global" was assigned to studies that included data from several locations around the world. "No region" was assigned to studies that were merely models without any location specifics (e.g. lab experiments or air flow computer simulations with a large variety of parameters).

Likewise, Figure 5.3 summarises the countries of study in alphabetical order. The countries with the highest number of studies included in the review are Germany and the USA with 8 studies respectively. I also assessed 6 items with case study data from Norway. 5 items were reviewed from both, Austria and The Netherlands each.

In terms of scientific field origin of the reviewed items, the highest number of studies was published in the environmental engineering field. However, it has to be pointed out that also closely related, and overlapping fields have been included, especially in terms of the water sciences and engineering

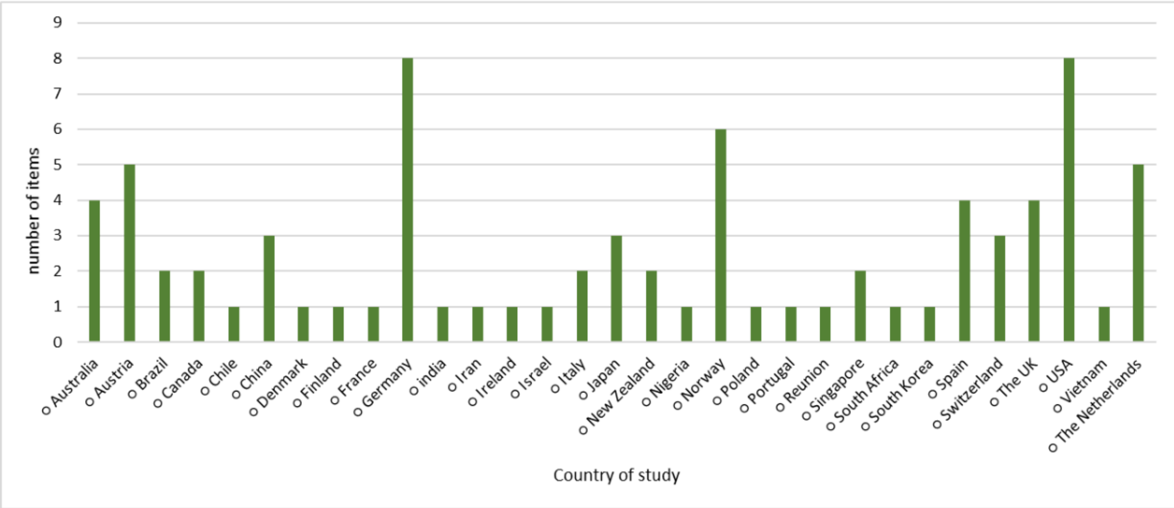


Figure 5.3: Countries of study in the 91 items of the literature review. Countries are only displayed here where the authors of the study gave a clear case study location indication.

fields. The categorisation followed the journals of publication and/or the departmental affiliation of the main author. The fields of architecture and environmental sciences are each represented with 10 studies, followed by urban development (8), civil engineering, geography and landscape planning (7 respectively). The lowest number of representation stem from within the geo-sciences and water sciences, as well as energy policy, meteorology and regional development. But, also here I want to highlight that the low number is due to the journal emphasis. The distribution of the reviewed items over the scientific fields can be seen in Figure 5.4

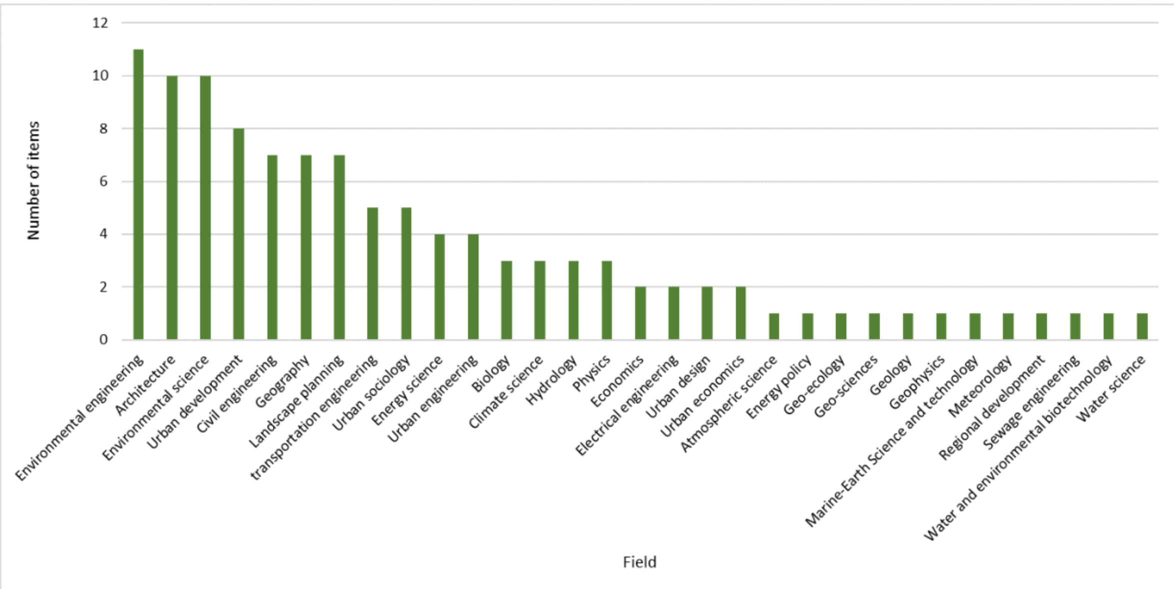


Figure 5.4: Overview of the fields of study of the items included in the literature review. The fields were assigned in line with the Journal as well as departmental adherence of the main author. The highest number of studies comes from environmental engineering publications, followed by architecture and environmental science fields.

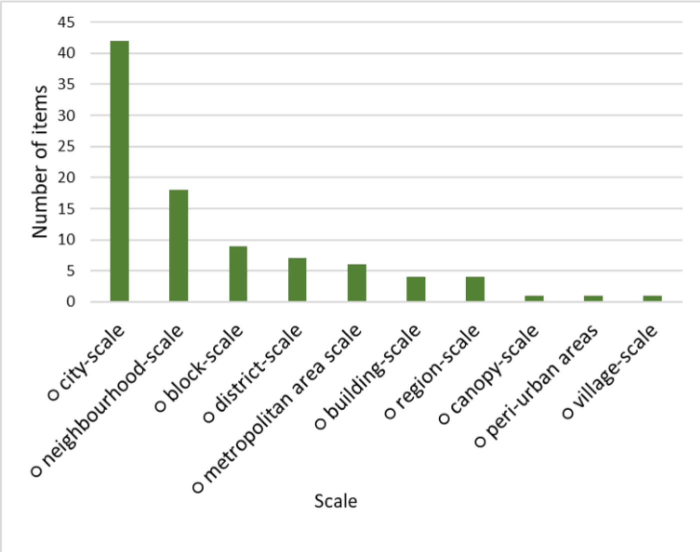


Figure 5.5: The majority of studies were conducted at city-scale, followed by neighbourhood and block-scale.

The scale at which the studies collected and evaluated their data was categorised into 10 scale levels. These range from building scale to block, neighbourhood and district scale, via city or village scale to the metropolitan area, peri-urban or regional scale. One more level was included, which was specifically observing the canopy scale. The majority of studies were conducted at city-scale (42), followed by neighbourhood (18) and block-scale (9). The count of studies per scale is represented in Figure 5.5.
Finally, the methods included to a large majority studies of spatial analysis, modelling or climate models and climate as well as urban development scenarios. Figure 5.6 provides the overview of study methods. The method categories relate to the method terminology used in the literature item. Therefore, overlaps certainly exist. Additionally, some of the published works generated results by a combined methods approach, increasing the number of study methods. Less dominant methods are data collected in surveys, interviews or field experiments. Such qualitative approaches are in the minority of the literature set. It can be seen that also 7 (literature) reviews and 3 framework definitions are part of the data set. This decision was taken as these studies, however not primary data collection methods, contribute to the body of literature as they formulate new conclusions based on the data taken from previous studies - as does this project.

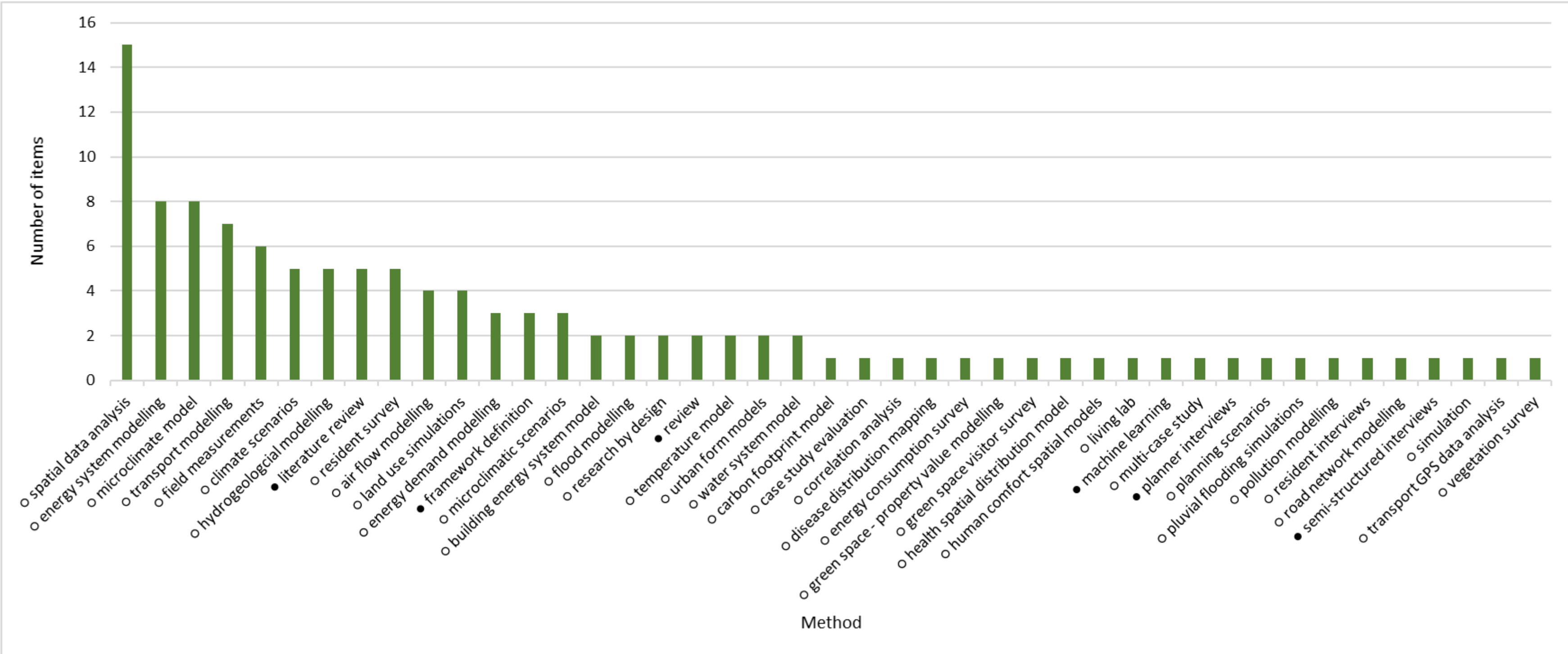


Figure 5.6: Overview of the methods of the included literature items. The method categories relate to the method terminology used in the literature item. The highest numbers of studies applied spatial data analysis (15), energy system modelling (8), micro-climate models (8) and transport models (7).

5.2. Knowledge base of social impacts

The final result of the literature review is the concept-centric knowledge base. It can be retrieved from the supplementary information, workbooks Appendix B.5.1. "KB-Stated-Review-DensificationThesis" and Appendix B.5.2 "KB-Reasoned-Review-DensificationThesis". These include the labelled quotations from the literature reviewed. B.5.1 comprises the stated, i.e. the explicitly mentioned social impacts. The impacts I reasoned from the literature, based on my conceptualisation, form workbook B.5.2. The sheets are the labels of the codebook. Each sheet catalogues the documents and quotations where identified impacts are stated or have been reasoned by me, based on the conceptualisation presented in Chapter 3. For instance, if looking for impacts on property values, then, the work sheet "property value" as label from the SI economic relations will display the documents and quotations where impacts on property values were either explicitly or implicitly mentioned, depending on the workbook. The other labels assigned to a quotation enable users to get indications for why this impact might have arisen, e.g. due to the UHIE, increased flood vulnerability, or drainage issues. Figure 5.7 shows a snapshot of the first two entries on the worksheet of property value impacts in the knowledge base of stated impacts in the literature review.

ID	Document	Document Groups	Quotation Content	Codes	Reference
14:14	2023_Erlwein et al. Governance of densification and climate change adaptation How can conflicting demands for housing and greening in cities be reconciled	CA:CCA Case Region	plans (Donner et al., 2017). Limited property rights and conflicting interests with private landowners are named as crucial challenges for green space planning in densifying city	impact equity&fairness (notions) ownership property value social differentiation/equity	10 - 10
24:21	2016_Byrne et al_Could urban greening mitigate suburban thermal inequity?: the role of residents' dispositions and household practices	CA:CCA	These results may be due to renters having little control over the appliances installed in their dwellings; it is landlords who make that decision. Landlords may act to limit financial outlays and to maximise their rental returns, seeing limited value in installing high-end, energy efficient appliances that could be damaged by tenants. Operating costs are not their concern because they are passed onto tenants (who pay for electricity).	autonomy compelling econ dependency & vulnerability ET_energy emerging tech ET_energy resources&generation housing quality impact equity&fairness (notions) income intersectional living standard needs vulnerable at home participation decisionmaking physical infra property value quote report social differentiation/equity	13 - 13

Figure 5.7: Knowledge base example: first two entries for stated property value impacts in the literature reviewed.

5.3. SI statistics in literature review data set

In this section, I am focusing on the occurrence of the SI and the social impacts labelled within the literature review data set. Table 5.1 shows the final SI occurrence in the literature review data set in absolute values and shares in % of stated and reasoned impacts.

The total (stated and reasoned) number of label occurrence per SI is: SI livability (218 %), SI health (170 %), SI economic relations impacts (132 %), SI community (105 %), SI institutional (49 %), SI culture (15 %) and SI gender (11 %). Overall, the SI livability was prevalent, with an occurrence of 36 % in the stated impacts and of 24 % in the impacts that I reasoned as implicitly observable in the literature. Here, I could identify a slightly higher share of 26 % of implicitly observed health impacts. Amongst the reasoned impacts, community impacts had a stronger representation than explicitly stated in literature, 20 % and 11 % respectively. Culture and gender impacts were close to absent. For both SIs, I reasoned them more often than such impacts were explicitly stated. However, their combined total share amongst the literature review items, is for both 2 %, with a more frequent occurrence of cultural impacts.

Table 5.1: Overview of social impact code occurrence in the literature data set of stated and reasoned social impacts. Per SI, the social impact occurrences are given in absolute values and percentage of the total stated, reasoned or combined occurrences.

Code Occurrence	Stated		Reasoned		TOTAL	
SI	absolute	share of stated (%)	absolute	share of reasoned (%)	absolute	share of Total (%)
Livability	145	36	73	24	218	31
Health	92	23	78	26	170	24
Economic relations	72	18	60	20	132	19
Community	45	11	60	20	105	15
Institutional	29	7	19	6	48	7
Culture	7	2	8	3	15	2
Gender	4	1	7	2	11	2
TOTAL	394	-	305	-	699	-

As Table 5.2 shows, the majority of literature in the case study region, see Section 4.4.2, focused on the livability impacts (33 quotations) of CCA and health impacts of CCA (24 quotations). The major ET related impacts were on livability (13 quotations) and economic relations (9 quotations). Additionally, in the literature set I labelled 8 quotations with stated impacts of CCA on economic relations and ET's impacts on health, respectively. In the interdependencies that I have reasoned, social trade-off were strongest in the same categories for the CCA domain only with a slightly higher number of quotations of health impacts (15) than livability impacts (12). For social impacts from the interplay of the ET and densification, I discerned health impacts 12 times in the studies observed, followed by generated community impacts, economic relations impacts, and livability impacts with 9 quotations respectively.

Table 5.2: SI outcomes if the knowledge base is reduced to the case region studies. Overview of number of quotations in the literature data set of stated and reasoned social impacts.

EXPECTATIONS in number quotations	stated		reasoned		TOTAL	
	absolute	share of stated (%)	absolute	share of reasoned (%)	absolute	share of total (%)
Livability	79	40	41	27	120	34
Health	46	23	43	28	89	26
Economic relations	27	14	28	19	55	16
Community	22	11	26	17	48	14
Institutional	15	8	7	5	22	6
Culture	5	3	5	3	10	3
Gender	4	2	1	1	5	1
TOTAL	198	-	151	-	349	-

5.4. Analysis in interdependency themes

5.4.1. Results on SI level, stated and reasoned

The statistics are distinguished for SI stated in the literature items and SI reasoned from the literature data. Table 5.3 shows the absolute number and share of stated impacts. Table 5.4 displays the results for impacts that I reasoned from the content of the literature review items.
For a graphic display, I refer to Figure 5.8 for the stated social impacts in the themes and Figure 5.9 for the social impacts I reasoned from the literature review. The values are given in absolute numbers.

The theme of the **UHIE, heat and drought,** was the most prevalent in the literature review data set. I identified an overall link number between this theme and the SIs in 200 instances. The most prevalent SI stated in literature was livability, 40.3 %, the most prevalent reasoned SI health, 35.5 %. In this theme, no gender impacts could be identified in the literature. Culture as well as institutional impacts of the UHIE were only stated twice, however, culture impacts made up for 1.3 % and institutional impacts for almost 4 % of the impacts that I reasoned due to the interdependencies between densification

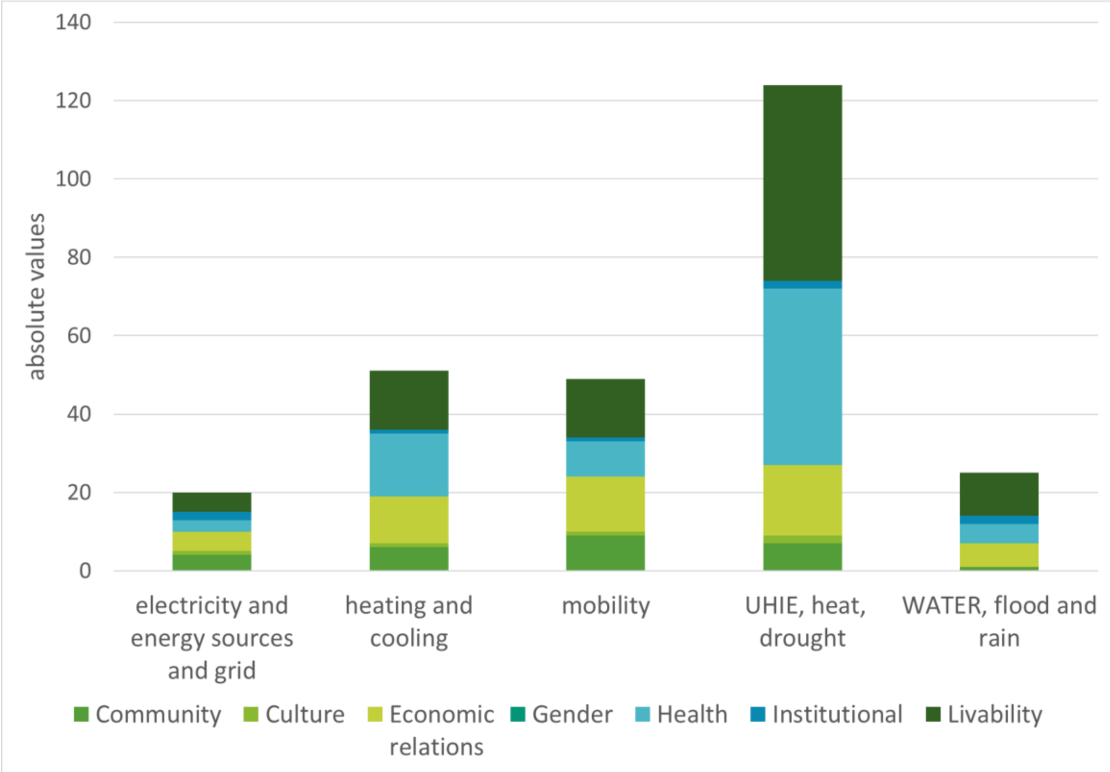


Figure 5.8: Main SI per theme stated in the literature review. Absolute Values.

and CA related to the UHIE.
Social impacts in the **WATER theme** I identified in 39 quotations. This ranks this interdependency only in the fourth place out of the five themes. Of the 25 instances that social impacts were explicitly stated, 44.0 % lay in the SI livability, followed by economic relations impacts at 24.0 % and impacts in the health SI at 20.0 %. Never stated nor reasoned were cultural or gender impacts, while one item in the literature review data set stated community impacts in one instance.

The **mobility** and **heating and cooling themes** were relatively similar with a total identification of 103 and 108 social impacts respectively. In both themes, I reasoned even more impacts that authors explicitly stated.
In the **mobility interdependency,** all SIs except gender counted at least one stated occurrence. Here, livability and economic relations impacts were most prevalent. In the impacts that could be reasoned from implicit content in the articles, all SIs were mentioned and the SI community abreast with the SI health at each 25.93 % in this theme.
In the **heating and cooling theme,** the most prevalent SI due to impacts stated in the literature was health, 31.37%, just ahead of livability, %29.41. Also in this theme no impacts in the gender SI were explicitly included in the studies. However I could defer one impact from the SI gender in the impacts that I reasoned from the data. Otherwise, the same SI were prevalent between reasoned and stated impacts.

In the theme of the **electricity and energy sources and grid,** the lowest number of impacts were identified. Similar to the UHIE and water themes, more impacts were stated than reasoned. Finally, economic relations and livability impacts were explicitly stated at the same frequency, making up 50 % of the stated impacts.

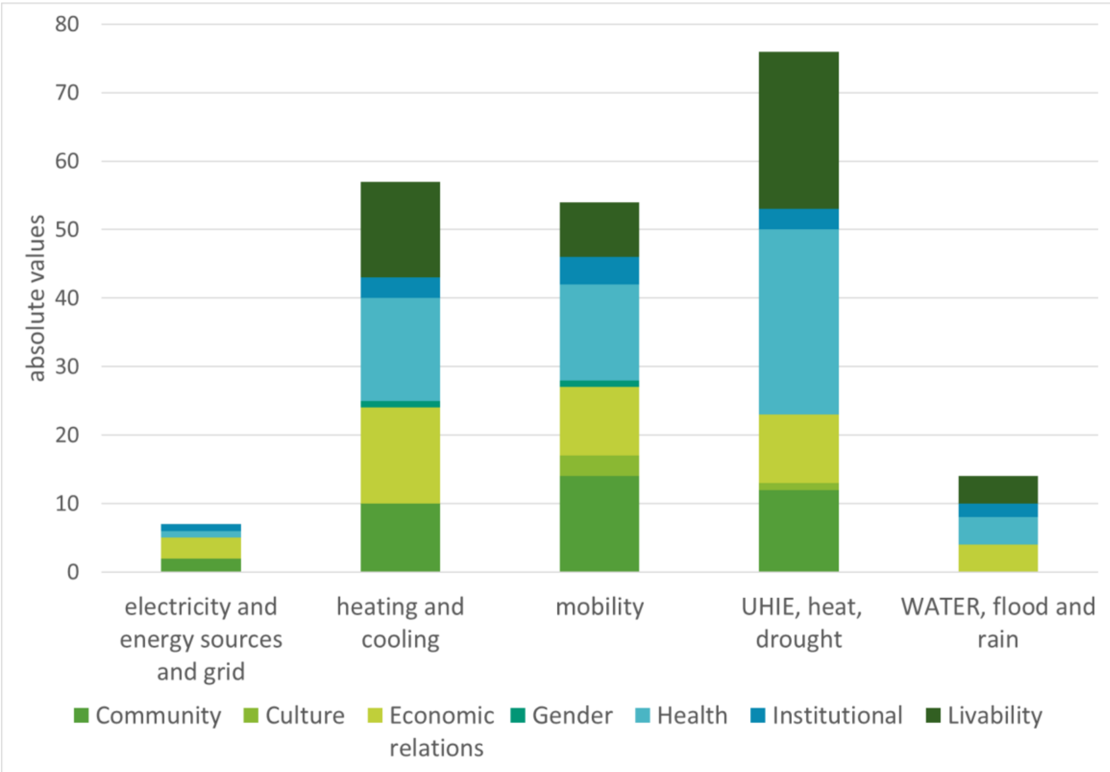


Figure 5.9: Main SI per theme reasoned from the literature review. Absolute Values.

Table 5.3: Overview of the absolute number and share of SI stated in the literature review data set arising from one of the five themes of interdependencies between densification and CA: 1) UHIE, heat drought, 2) Water, floods and rainfall, 3) Mobility, 4) Heating and cooling, and 5) Electricity and energy sources and grid.

STATED LITREV	electricity and energy sources and grid		heating and cooling		mobility		UHIE, heat, drought		WATER, flood and rain	
SI	absolute	share	absolute	share	absolute	share	absolute	share	absolute	share
Community	4	20,00%	6	11,76%	9	18,37%	7	5,65%	1	4,00%
Culture	1	5,00%	1	1,96%	1	2,04%	2	1,61%	0	0,00%
Economic relations	5	25,00%	12	23,53%	14	28,57%	18	14,52%	6	24,00%
Gender	0	0,00%	0	0,00%	0	0,00%	0	0,00%	0	0,00%
Health	3	15,00%	16	31,37%	9	18,37%	45	36,29%	5	20,00%
Institutional	2	10,00%	1	1,96%	1	2,04%	2	1,61%	2	8,00%
Livability	5	25,00%	15	29,41%	15	30,61%	50	40,32%	11	44,00%
TOTAL	20	100,00%	51	100,00%	49	100,00%	124	100,00%	25	100,00%

Table 5.4: Overview of the absolute number and share of SI reasoned in the literature review data set arising from one of the five themes of interdependencies between densification and CA: 1) UHIE, heat drought, 2) Water, floods and rainfall, 3) Mobility, 4) Heating and cooling, and 5) Electricity and energy sources and grid.

REASONED LITREV	electricity and energy sources and grid		heating and cooling		mobility		UHIE, heat, drought		WATER, flood and rain	
SI	absolute	share	absolute	share	absolute	share	absolute	share	absolute	share
Community	2	28,57%	10	17,54%	14	25,93%	12	15,79%	0	0,00%
Culture	0	0,00%	0	0,00%	3	5,56%	1	1,32%	0	0,00%
Economic relations	3	42,86%	14	24,56%	10	18,52%	10	13,16%	4	28,57%
Gender	0	0,00%	1	1,75%	1	1,85%	0	0,00%	0	0,00%
Health	1	14,29%	15	26,32%	14	25,93%	27	35,53%	4	28,57%
Institutional	1	14,29%	3	5,26%	4	7,41%	3	3,95%	2	14,29%
Livability	0	0,00%	14	24,56%	8	14,81%	23	30,26%	4	28,57%
TOTAL	7	100	57	100	54	100	76	100	14	100

5.4.2. Results on individual social impact level, stated and reasoned

On the level of social impacts, Table 5.5 shows the most frequently identified stated social impacts of the literature review data set in connection with the five themes. Table 5.6 provides the main impacts extracted via reasoning from the literature review data. The number of instances the social impact was labelled is given in "(...)".

In all five themes, impacts on well-being and actual health in the UHIE theme were the most prominent and had similar strong representations in the other themes. In all themes, income impacts were amongst prevalent impacts. Except in the Water interdependency, the social differentiation impacts were amongst the prevalent impacts of identified stated impacts. Cohering to the nature of this theme, access to public services and routine disruption are only found in prevalent individual social impacts in the mobility theme. Autonomy impacts were still quite prevalent in the autonomy theme. Lastly, economic relations impacts aside income and living standard were prevalent in the electricity and energy sources and grid (economic dependency and vulnerability), mobility (employment options), Water (employments options, economic prosperity and resilience). Interestingly, the environmental amenity value is stated as impacted in 10 instances in the UHIE theme (out of 158 quotations).

The impacts that I reasoned from the data where I identified them as implicit in the work added several facets to the impacts stated. For instance, autonomy impacts took on an even stronger role in the mobility theme. In this interdependency, I could then also depict cultural values and aesthetic quality impact. Impacts on the latter were added to the UHIE theme as well as impacts on the perception of the quality of the built environment. In the water as well as in the electricity and energy sources and grid themes, property values were amongst the most prevalent individual social impacts. Lastly, in the water theme, impacts on the government workload and viability found entrance as well.

Additionally, Table D.1 in the Appendix shows the most frequently identified stated social impacts in the literature review data set reduced to the AMS-region in the five themes. Table D.2 provides the main impacts additionally identified via reasoning in the literature review data set reduced to Amsterdam. As the number of labelled quotations became smaller, the diversity in the most prevalent identified individual social impacts grew. In this observation the impact of energy expenses, combining living standard and income in the context of heating and cooling energy expenses became relevant in the impacts stated in the data.

Table 5.5: Prevalent individual social impacts per theme stated in the literature review (ranked by frequency). The total stated number of quotations in this theme is given in the top row.

electricity and energy sources and grid Top 21 of 29 quotations	**heating and cooling Top 52 of 71 quotations**	**mobility Top 46 of 62 quotations**	**UHIE, heat, drought Top 112 of 158 quotations**	**WATER, flood and rain Top 24 of 34 quotations**
living standard (4)	well-being (10)	social differentiation (8)	well-being (31)	physical infrastructure (6)
physical infrastructure (4)	living standard (8)	leisure and recreation (6)	actual health (21)	actual health (4)
social differentiation (4)	actual health (7)	living standard (6)	actual quality (16)	actual quality (3)
econ. dependency and vulnerability (3)	income (7)	autonomy (4)	physical infrastructure (15)	economic prosperity and resilience (3)
autonomy (2)	physical infrastructure (6)	employment options (4)	environmental amenity value (10)	actual safety (2)
housing quality (2)	social differentiation (6)	access to public services (3)	social differentiation (7)	employment options (2)
income (2)	actual quality (4)	actual health (3)	income (6)	environmental amenity value (2)
	housing quality (4)	actual quality (3)	living standard (6)	income (2)
		income (3)		well-being (2)
		physical infrastructure (3)		
		routine disruption (3)		

Table 5.6: Prevalent individual social impacts per theme reasoned from the literature review (ranked by frequency). The total stated number of quotations in this theme is given in the top row.

electricity and energy sources and grid 8 quotations	**heating and cooling Top 55 out of 79 quotations**	**mobility Top 41 out of 73 quotations**	**UHIE, heat, drought Top 67 out of 105 quotations**	**WATER, flood and rain 19 quotations**
living standard (3)	living standard (11)	autonomy (12)	well-being (21)	actual health (4)
social differentiation (2)	well-being (10)	actual health (5)	actual health (15)	property value (2)
autonomy (1)	social differentiation (9)	living standard (5)	leisure and recreation (8)	envtl amenty value (2)
participation decisionmaking (1)	actual health (7)	leisure and recreation (4)	perception quality (7)	actual quality (1)
property value (1)	social quality (6)	aesthetic quality (3)	actual quality (5)	actual safety (1)
	autonomy (4)	cultural values (3)	aesthetic quality (5)	autonomy (1)
	leisure and recreation (4)	income (3)	living standard (5)	econ dependency & vulnerability (1)
	perception quality (4)	physical infrastructure (3)	social differentiation (10)	govt workload viability (1)
		social differentiation (3)	social quality (7)	housing quality (1)
				income (1)
				living standard (1)
				local economic disruption (1)
				participation decisionmaking (1)
				well-being (1)

Chapter 6

Case study: Description and Results

This chapter first provides the description of the choice for urban densification in Amsterdam, in Section 6.1.1, and of the city's CA pursuits, Section 6.1.2. Then, mirroring the previous chapter, I present the major statistics of social impacts stated in the interviews and reasoned from the interview content. In Section 6.3.1 I do this on the overall level of SI in this perspective. Then I break down the results to the level of the most prominent individual social impacts in the themes in Section 6.3.2. I conclude this chapter with the presentation of the general densification perception of the interview participants in Section 6.4, and the issues that emerged at the interface of the transitions in the context of Amsterdam, see Section 6.4.1.

6.1. Case study description

Due to the city's topography and history, spatial planning is elementary and part to the city's well-being. An early example are the wooden poles that were driven into the soil to stabilise the ground and the *polder* lands surrounding the city (Nijhuis, 2020; Ven et al., 2004). With the importance of the harbour with access to the river IJ, the North Sea and the *IJsselmeer*, and the water management infrastructures of the canals and dykes, the city is highly aware of its dependency on the environmental circumstances and the risks resulting from climate change. As public space and means are limited, and sustainability goals have found ways into the government agenda, the city's policy aims at a densifying development, which is making use of the existing housing stock within the current city boundaries (Gemeente Amsterdam, 2023k).

6.1.1. Densification in Amsterdam

The choice to densify

The Amsterdam Metropolitan Region (AMR), see Figure 6.2, currently amounts to 2.5 Million inhabitants and 30 municipalities which are working together for instance in mobility or economic development policy (Metropoolregion Amsterdam, 2023). The metropolitan region is located in an area of 2,580.26 km^2, and has access to the North Sea, the river IJ and the IJsselmeer, an inland lake which was synthetically created through the Dutch water management plans (Metropoolregion Amsterdam, 2023).

Figure 6.1 displays the city of Amsterdam and its location in the Netherlands. The population in the city is growing. The current rate amounts to a **growth of about 11,000 new inhabitants annually** (Gemeente Amsterdam, 2023e). In 2023, the population of the municipality of Amsterdam was 918,193, including a share of 16.1 % minors (Gemeente Amsterdam, 2023a).

The housing stock in the city amounts to **474,735 registered addresses in 2021**, which included houseboats and caravans. The densest districts are the center and the surrounding districts. In the complete city, about 29% residents live in their own flat or house, 31.4 % are rented out directly from private owner to tenant and the remainder of 39.5 % of dwellings is rented via co-operations or corporations (Onderzoek en Statistiek Amsterdam, 2023). In the seven years **between 2015 and 2022** the city of **Amsterdam experienced a 144 % price increase of ownership housing and a 42 % rent increase for non-social housing flats** against a **19 % rent increase in the social housing sector**. This increase was unequally distributed across the city. The highest increases took place in the neighbourhoods surrounding the center (Gemeente Amsterdam, 2023k).

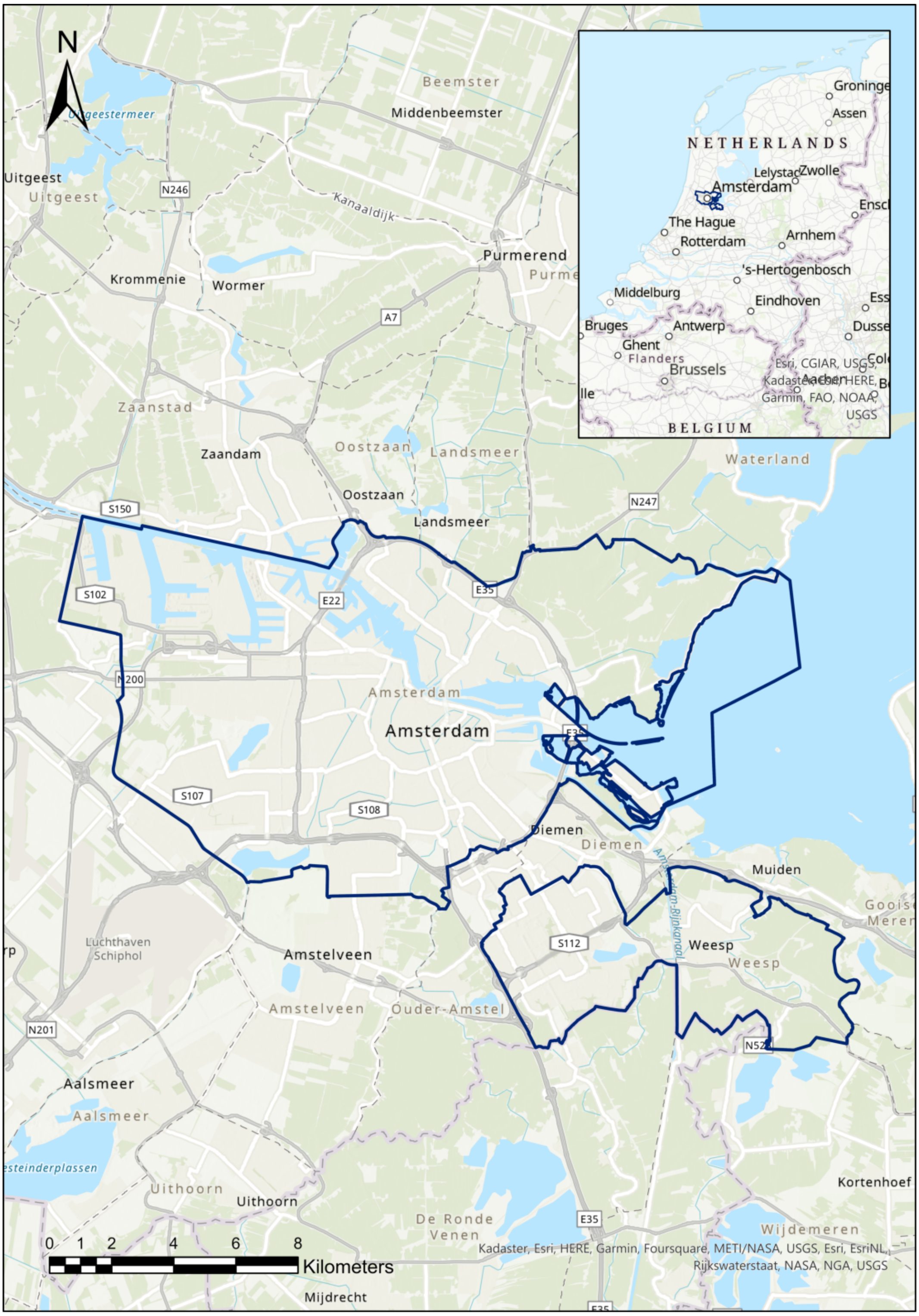


Figure 6.1: Map of the city of Amsterdam and location within the Netherlands.

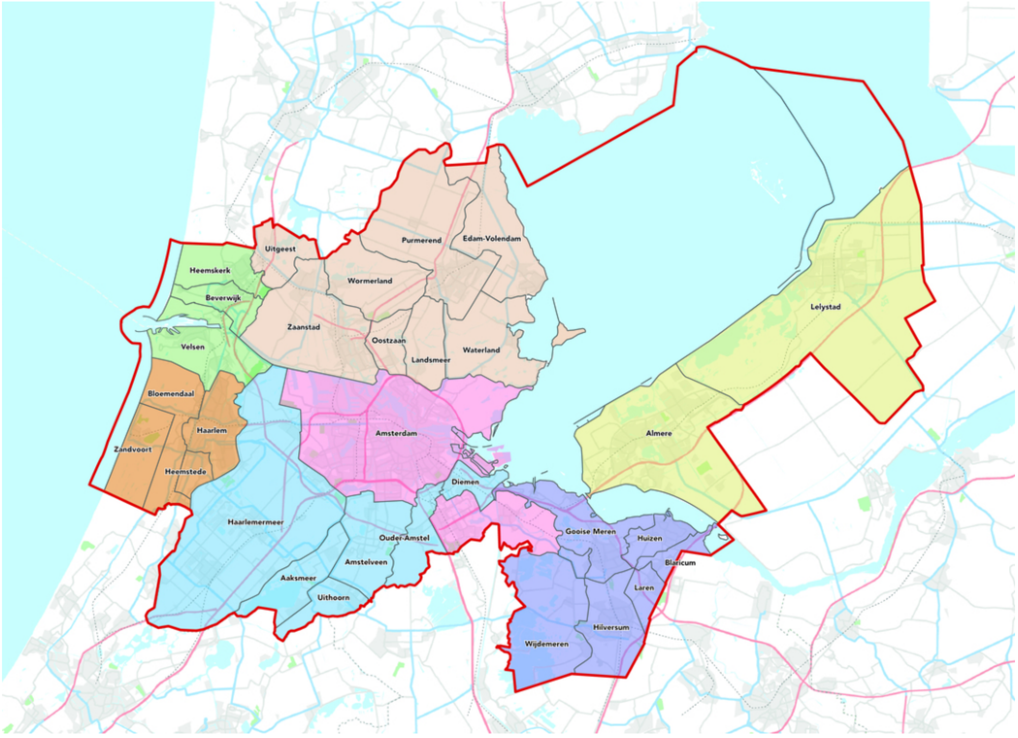


Figure 6.2: Map of the Amsterdam Metropolitan Region consisting of 30 municipalities, the two Dutch provinces North-Holland and Flevoland and the public transport region "Vervoerregio Amsterdam" (Metropoolregion Amsterdam, 2023).

Forecasts estimate the housing stock to grow up to almost 510,000 in 2030 and **588,500 in 2050** (Onderzoek en Statistiek Amsterdam, 2023). Already in 2016, the city council gave the order to look into densification within the city boundaries until 2025. In particular in the outer districts, densification potentials were found and identified to be possible either through topping-up of existing blocks, high-rise infilling, and the transformation of transport areas or former business areas (Ruimte en Duurzamheid Amsterdam, 2017).

The densification goals

To achieve the goal for 2050, just below 4000 housing units would need to be built annually. The city's coalition government has announced the **goal to create 7,500 additional housing units per year**, to also account for future incoming residents. Not only the availability of housing, but also the affordability of housing has to be provided for if the urban social fabric ought to be maintained and conflicts and financially struggling residents prevented. **The aim is to provide 40 % social housing units, 20 % of these in the free market and 40 % in the so-called "middeldure sector"** to provide a larger number of affordable housing units and shorten waiting lists (Gemeente Amsterdam, 2023k).
The municipality has to **provide a variety of urban public services and functions** in parallel to housing units. Jobs, public health services, recreation and social infrastructures. In the plans of the city, this is not only happening on the municipal level, but functions are planned for the whole metropolitan region and also in alignment with national plans (Gemeente Amsterdam, 2023h, 2023k). These other functions compose public services in the proximity of residents and providing citizens with distances which are at best walkable (Gemeente Amsterdam, 2023k). The full list of land use area and the functions located on these areas, ranging from housing to mobility, employment and necessary infrastructures is displayed in Table 6.1.

Densification strategy in review

In April and May 2024, the municipality of Amsterdam conducted public participation meetings in various neighbourhoods of Amsterdam. In these meetings, the drafted densification variants were presented and the main values, ideas and demands of the residents in the audience requested. I was

Table 6.1: Elements of urban densification making up the understanding of densification in this thesis project. Taken from the densification strategies of the municipality of Amsterdam (Gemeente Amsterdam, 2023k).

Mixed use functions	land use area
living space/housing units	built environment area - buildings
amenities (e.g. supermarkets, pharmacies, recreational areas)	built environment area - infrastructure
public services (e.g. administration, healthcare) and institutions (e.g. daycare, education, libraries, culture)	green space area
human transportation = "mobility" (individual motorised = by use of electric or combustion engine vehicles, or unmotorised transport = cycling or walking, public transportation services)	-
commercial transportation/transportation of goods	-
occupational space/employment options	-
technical infrastructures for these functions	-

able to listen in and observe in one of these participatory meetings. The process was concluded in July. At the time of writing this report, the concept of the densification strategy, the "Ontwikkelstrategie 2035" was under development and to be read in November 2023. The objection phase is planned for December 2023 and the decision in the municipal council for April 2024.

The variants discussed Table 6.2 lists the elements discerned from the four densification strategies of the municipality of Amsterdam: *Nieuwe Wijken* (new neighbourhoods), *Stationskwartieren en Stadslanen* (station quaters and transport lanes), *Stadsdeelcentra* (neighbourhood centers) and *Verbetering Bestaande Woonbuurten* (existing neighbourhood development) (Gemeente Amsterdam, 2023k; van Dort et al., 2023). The possible locations in the city are visualised in in Appendix D.2 and the descriptions from Gemeente Amsterdam (2023k) are summarised below:

- The variant **New Neighbourhoods**, combines sprawl and transformation of office parks, harbour and industrial areas. Current business might be requested to move to outskirts and be replaced with other businesses or residential buildings to create mixed use function neighbourhoods. Amenities that need to be accommodated are public transport, green space, shops, workshops and schools. These services shall also improve their accessibility in surrounding neighbourhoods. The possible locations are visualised in Figure D.1.
- In the variant **Neighbourhood Centers** [July 2023: Business centers and innovation and knowledge centers], shopping centers and knowledge institutions are already present infrastructure items. On top of this buildings, addition residential units may be constructed. While the transportation in these locations mainly relies on walking and cycling due to short distances, it will be necessary to increase the area of green and public space if the resident population increases. As these areas also include innovation centers and institutions of higher education, units for students, scientists and healthcare staff are planned. The possible locations are visualised in Figure D.3
- **Station Quarters and Transport Lanes** is a variant that aims at good mobility nodes to provide accessibility, so-called hubs, where transport modes may be changed. This variant focuses on the establishment of new neighbourhood facilities and workplaces, rather than housing construction. The housing units that are incorporated into this area are for small household sizes. On former city lanes, neighbourhood facilities or smaller office and business buildings will be constructed. The transformation of streets for cars into bicycle streets is possible. In terms of energy system infrastructure, the developed areas and surrounding neighbourhoods may be connected with extended heating district pipelines and renewable energy systems. The possible locations are visualised in Figure D.2.

- The variant **Existing Neighbourhoods** involves often small-scale and diverse projects, oriented at the existing building stock. The increase of residents makes more facilities viable to also serve current residents. To prevent increased car traffic, investments into fine-mesh public transport and bicycle connections are planned. These ought to also ensure upkeep of the transport infrastructures and amenities and public services in place. As topping up of buildings is in the focus, it is aimed at scaling up the number of housing units. The possible locations of this variant are visualised in Figure D.4.

Table 6.2: Elements discerned from the four densification strategies of the municipality of Amsterdam: *Nieuwe Wijken* (new neighbourhoods), *Stationskwartieren en Stadslanen* (station quaters and transport lanes), *Stadsdeelcentra* (neighbourhood centers) and *Verbetering Bestaande Woonbuurten* (existing neighbourhood development) (Gemeente Amsterdam, 2023k).

Nieuwe Wijken new neighbourhoods	**Stationskwartieren & Stadslanen Station quaters and transport lanes**	**Stadsdeelcentra neighbourhood centers**	**Verbetering Bestaande Woonbuurten existing neighbourhood development**
newly declared land	existing stations/ transport lanes	close amenities, work, education	existing social and physical structures
mixed use: live, work, amenities	strengthening public transport and bikes	biking, walking, mobility reduction	small scale addition
transformation harbour area	reduction car space and speed	bringing housing to amenities	demolition and reconstruction
new public transport, bike and mobility hubs	business space stations	closing amenity and public space gaps	local business space
new amenities and public services	business space transport lanes	more culture and business	local job creation
transformation industrial area	(shared) mobility hubs "P&R"	innovation industry space	neighbourboods hubs, small-scale public transport, bikes
transformation commercial area	bike lane carrier	logistics hubs	combination reconstruction
moving business	culture and education	attractive clusters	topping-up
new green space	neighbourhood services	space for more green	added amenities, services
-	small and roof leisure green space	small housing units	increase quality for current residents
	green lanes to outskirts and parks	-	-
	remove barriers		
	connecting neighbourhoods		
	heat/energy network connection		
	small housing units		

6.1.2. CA in Amsterdam

CA in the National Spatial Vision (NOVI)

In the Netherlands, the energy transition constitutes a policy goal of the National Spatial Vision (NOVI). The NOVI highlights the use of hydrogen and green gas, the importance of charging infrastructure, mobility, heat networks and solar PV. Moreover, the vision specifically not only recognises the power of a combination of tasks, but also, the (over-)crowded urban underground environment, with a high competition between cables, pipelines and other use and maintenance processes in the sub-surface level (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2020, pp. 82–84). In the context of CCA, the national spatial vision (NOVI) calls for particular attention and inclusion of infrastructure elements, namely "[...] energy, telecommunications, IT facilities, national security, main infrastructure, water and healthcare facilities" (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2020, p. 76) in CCA. This showcases the comprehensive recognition of built infrastructure demands in CCA, increasing the demand for urban space.

CA in the municipal Spatial Vision of Amsterdam (OV)

In the spatial vision of Amsterdam, the *Omgevingsvisie* (OV), six overarching goals are included: 1) inclusive city, 2) sustainable city, 3) vital city, 4) healthy city, 5) livable city, and 6) compact city (Gemeente Amsterdam, 2023j). The OV was confirmed by the city council in 2021 and is the follow-up policy on the structural vision for Amsterdam 2040 ("Structuurvisie Amsterdam 2040) of 2011 (Gemeente Amsterdam, 2023j). The tool of densification represents the sixth of the objectives. The CA related transitions originate from the second objective, the provision of a sustainable city. All three transitions that are subject in this thesis project create spill-over effects to the other four objectives.

In the municipal agenda, policy goals are set for 2030, 2040 and 2050, see Figure 6.3. The city's sustainability agenda strives to achieve residential electricity use to at least 80 % from solar and wind, eliminate natural gas as energy source, and reduce CO2 emissions by 55 to 60 % in comparison with 1990. This shall be made possible by a reduction of material use by 50 %, "circularity" and lead to climate neutrality and climate adaptability. An ambitious agenda, the tools for this sustainability transition are pursued to be the ET and CCA, next to the establishment of a circular economy and the promotion of technology and innovation. The change processes are aiming at a broad inclusion of the city's residents and requesting in particular owners to participate in energy use reduction measures and the setup of solar PV and green roofs where possible (Gemeente Amsterdam, 2023f). Monitoring these policies lies at the heart of enforce-ability and re-adjustment of interventions. With the Amsterdam Circularity Monitor (Gemeente Amsterdam, 2023d) and the municipal statistics service (Gemeente Amsterdam, 2023a), CA transitions may be assessed.

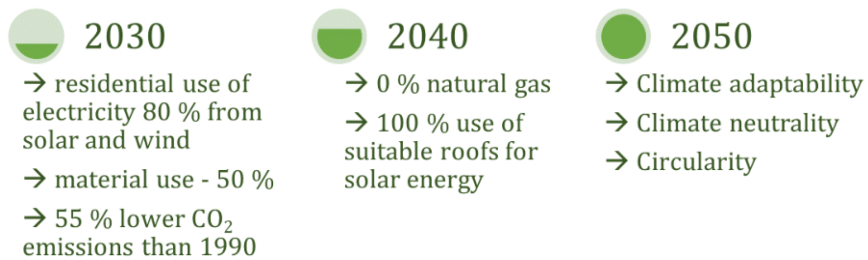


Figure 6.3: The pathway for Amsterdam's sustainability goals for 2030, 2040 and 2050. Electricity sources as much as possible from solar and wind, emission and material use reductions and, by 2050, climate adaptability, neutrality and circularity (Gemeente Amsterdam, 2023f).

These principles also form the foundation of the city's urban development, manifested in the city doughnut, see Figure 6.4 (Doughnut Economics Action Lab (DEAL) et al., 2020). This agenda follows the doughnut economics of Kate Raworth (2017), which aims at an economy staying within the safe and just space.

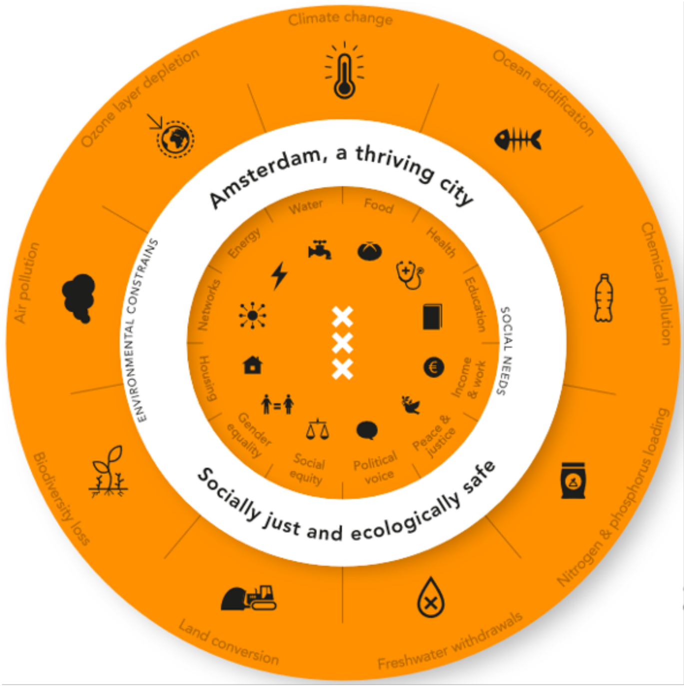


Figure 6.4: Amsterdam City Doughnut, designed by Doughnut Economics Action Lab (DEAL) et al. (2020) and following the doughnut economics model (Raworth, 2017).

CCA

On the side of CC impacts and sources, 81 % of Amsterdam's CO2 emissions arise from material use - which to a major share creates emissions outside the city boundaries, up and down the supply chain. To mitigate this, the city government mainly supports CE based policies. On the side of CCA, heat, drought, floods and ground subsidence are the extreme weather events and consequences which the city is preparing for. The municipal agenda is highlighting the social impacts, in terms of accessibility of health, education and other public services. To adapt to these changing conditions, the municipality has a strong focus on the needs of vulnerable groups on the one hand and the participation of residents with means and adaptive capacity on the other (Gemeente Amsterdam, 2023c). In housing development, the minimum rainfall storage limit of 60 mm per hour is prescribed. This water then has to be drained within 60 hours. For critical infrastructure, a minimum limit 90 mm per hour has to be stored. The city recommends the implementation of nature based solutions for permeability and storage, as well as the reduction of heat stress (Gemeente Amsterdam, 2023c).

The ET

In 2022, the share of fossil fuel sources (oil, coal and natural gas) used in the Netherlands at 56%. The share of renewable sources of energy (hydropower, solar, wind, geothermal, bioenergy, wave, tidal energy) at 14 %. The largest share of electricity production sources in the same year was attributed to gas at 39%, followed by wind at 17%. In terms of energy use trends, energy intensity (the primary energy consumption per unit of gross domestic product) and carbon intensity (the amount of CO2 emitted per unit of energy production) have been going down steadily in the past decades (Ritchie et al., 2022).
But, to keep up with the expected rise in electricity demand due to an electrification and increased use of renewable sources (minimum tripling in the case of the city of Amsterdam) new and more sources are necessary. The municipality is planning to double electricity grid's capacity until 2050. The works are planned to take place from 2023 until at least 2035, with a focus on the addition of electricity stations and transformation stations from medium to low voltage. Next to this infrastructure and connections in the form of cables, the municipality aims at the integration of renewable energy sources and smart electricity control systems (Gemeente Amsterdam, 2023b).

Mobility

In the Netherlands, the share of EV (Battery Electric Vehicles, Fuel Cell Electric Vehicles, Plug-in Hybrid Electric Vehicles) has ben steadily on the rise (Netherlands Enterprise Agency (RVO), 2023).
The city's mobility agenda *Mobiliteitsaanpak Amsterdam 2030* in 2015 encompassed the introduction of a speed limit to 30 km/h in the center, new bike lanes as well as bike bridges connecting the center and South of the city with the Northern development areas. Parking was to move underground as much as possible. To improve the traffic flow, the public transport ought to be further promoted, and the areas for pedestrians and cyclists upgraded. Car mobility has been in the focus to provide fast connections between the city and the surrounding areas, with an increase in park and ride options at the city boundaries. Another link with the AMR was aimed at by the establishment of metropolitan bike lanes as edges between Amsterdam and the other municipalities in the AMR (Gemeente Amsterdam, 2023i; Gemeente Amsterdam - Verkeer en Openbare Ruimte, 2015). To cut down mobility emissions, the current municipal government agreed on the establishment of emission free zones within the inner city ring. This applies for newly registered vehicles starting in 2025. Already registered vehicles will not be affected until 2030. For this shift, the council plans to establish charging stations, and subsidises the vehicle exchange and dissemination campaigns (Gemeente Amsterdam, 2023c).

Green space and recreation

In terms of green space, the green vision, *Groenvisie, een leefbare stad voor mens en dier 2020-2050* presents the city's aims of the availability of green areas: Within 10 minutes walking, city residents should be able to reach a oark, within 15 minutes cycling, larger nature areas. Access to formerly restricted areas such as school gardens should be opened up as much as possible and built structures as much as possible be replaced by nature based solutions. For instance concrete and asphalt by permeable and green structures. The replacement of grey structures and increase of green structures through residents is subsidised by the municipality. Additionally, the creation of fully new green space in the form of food forest, city parks and a city forest is envisioned until 2050 (Gemeente Amsterdam, 2023g). The current coalition agreement emphasised the impact of street trees, green roofs, facades and the actual biodiversity value of green area designs ((PvdA) Moorman et al., 2022). In its 2021 sports and recreational agenda, the municipality looked at the locations where residents do sports. About half of sportive activities are conducted within the residential neighbourhood and about 15 % within the city district of living (Gemeente Amsterdam, 2021). This emphasises the need for the municipal agenda to include individual activity and sports areas into the densification planning of neighbourhoods.

Electricity grid, heating and cooling

Insulation of the existing housing stock, high standard construction of new buildings, the promotion of higher building standards in development projects are part of the energy use reduction agenda of Amsterdam. Next to this use phase transition, the energy sources are in focus of the municipal ET. The The district heating network agenda is under revision until 2024. Other energy sources, such as heat pumps, aqua-thermal energy for heating and wind and solar for electricity production form the municipal portfolio. Hydrogen technologies are particularly aimed at for industrial uses. These transitions are often in the focus of public-private knowledge exchange in cooperation with owner associations and housing corporations (Gemeente Amsterdam, 2023c)

6.2. SI statistics in interview data set

Table 6.3 shows the number of quotations explicitly mentioned (stated) or implicitly reasoned (reasoned) as social impacts between densification and the ET and CCA. The table includes first and second order impacts generated through these change processes. The largest number of social impacts was stated and reasoned for livability (66), followed by health (56) and economic relations impacts (42). The interviewees spoke about impacts concerning the community (30) and institutional relations about half as much. Gender impacts (2) and cultural impacts (2) were almost not represented in the interviews. The interview participants elaborated on the social impacts arising from interdependencies between the ET and densification (109) about twice as often as on impacts interpreted as arising from CCA and densification (63).

Table 6.3: Overview of number of quotations in the interviews of stated and reasoned social impacts.

Code Occurrence in labelled quotations	stated		reasoned		TOTAL	
SI	absolute	share of stated (%)	absolute	share of reasoned (%)	absolute	share of total (%)
Livability	98	31	29	18.24	127	27
Economic relations	69	22	26	16	95	20
Health	59	19	43	27	102	21
Community	45	14	34	21	79	17
Institutional	31	10	20	13	51	11
Culture	8	3	3	2	11	2
Gender	6	2	4	3	10	2
TOTAL	316	-	159	-	475	-

6.3. Results in interdependency themes

In this section I set the SI and social impacts perceived by the interviewees into the context of the five interdependency themes. In Section 6.3.1 I do this on the level of the SIs. In Section 6.3.2 I will zoom into the individual social impact level for extracted examples at the hand of quotes from the interviews.

6.3.1. Results on SI level

The statistics are distinguished for SI stated in the interviews and SI reasoned from the interviewees' statements. Table 6.4 shows the absolute number and share of stated impacts. Table 6.5 displays the impacts that I reasoned from the the interviews.
For a graphical display, refer to Figure 6.5 for the stated social impacts in the themes and Figure 6.6 for the social impacts I reasoned from perceptions of the interviewees. These are presented in absolute numbers.

In the **theme of the UHIE, heat and drought,** almost half of the impacts the interviewees stated were in relation to the SI health. More than a third connected to livability impacts. None of the interviewees stated social impacts in this theme in the categories of community, culture, gender or institutional impacts.
In the impacts that I reasoned, in the theme of the UHIE, community impacts joined livability impacts as the most prevalent additional impacts with each a third of quotations. But also in the reasoned impacts, the SIs culture, gender and institutional impacts were absent from the data.
I identified community impacts in five instances in this theme due to my reasoning. Culture, gender and institutional SI impacts remained absent from the data in this theme. In the **WATER theme,** the participants stated prevalent impacts for livability and economic relations, 37.04 % and 33.33 % respectively. Also impacts in the health Si were frequent, while only one participant explicitly referred to an institutional impact in this theme.
The interdependency with the largest amount of stated impacts, **mobility**, the most frequent SI remained livability and health, followed by economic relations.

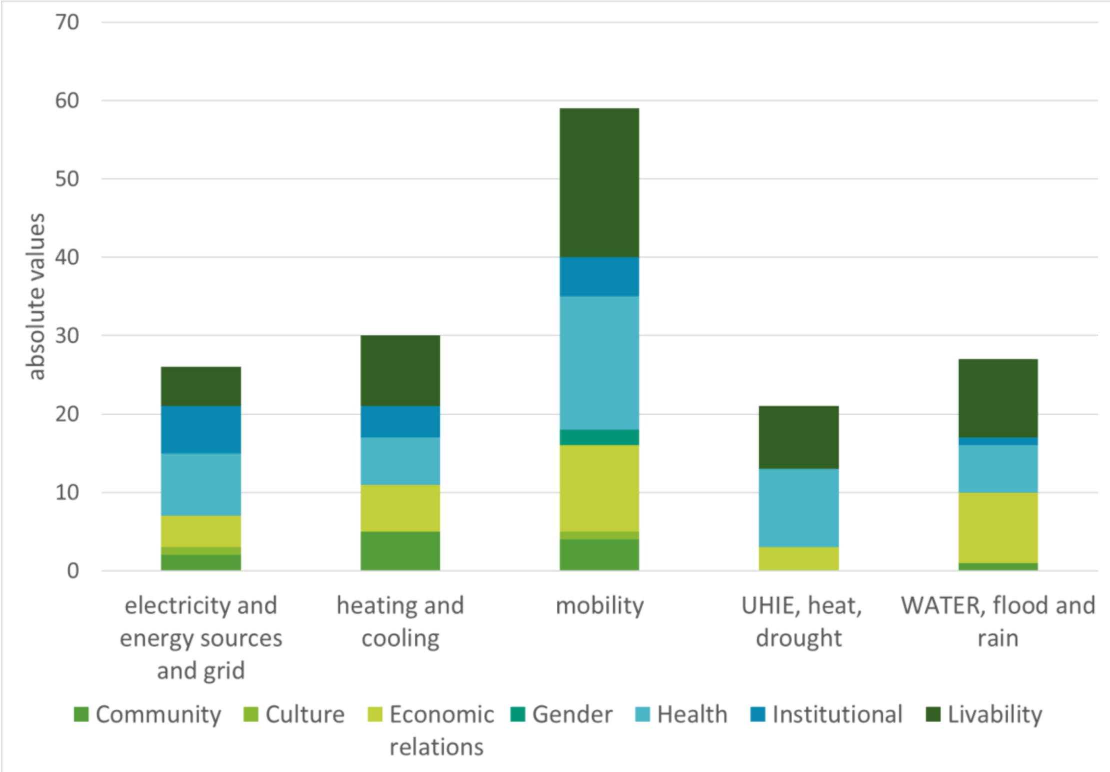


Figure 6.5: Main SI per theme stated in the interviews. Absolute Values.

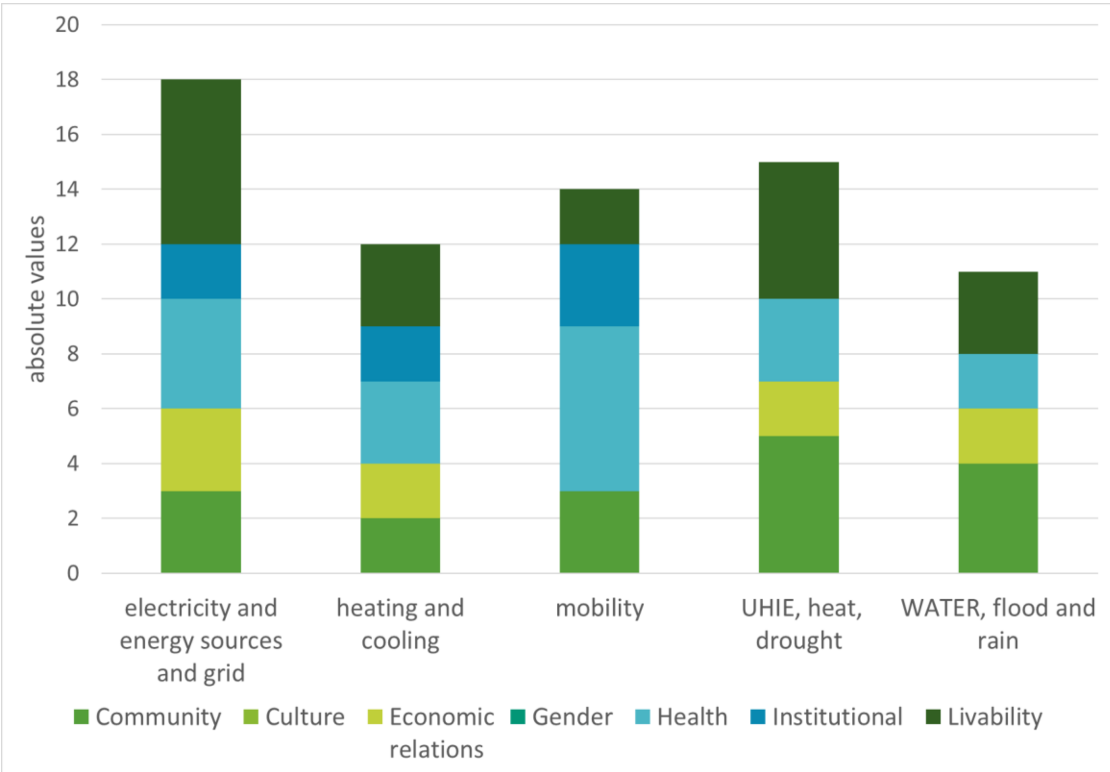


Figure 6.6: Main SI per theme reasoned from the interviews. Absolute Values.

In the mobility theme, more than a fifth of reasoned impacts I identified in the themes of community and institutional (3 quotations respectively). Nonetheless, the most prevalent SI in terms of social impacts implicitly perceived by the interviewees was health.
Looking at **heating and cooling,** as well as **electricity and energy sources and grid,** the interviewees stated a wider range of impacts than in the other themes. In the former, community and institutional impacts joined the prevalent impacts. In the latter theme institutional impacts and community and cultural impacts were stated. Neither in the heating and cooling interdependency, nor in the electricity and energy sources and grid theme culture or gender impacts were reasoned from the interviewee's perceptions.

Table 6.4: Overview of the absolute number and share of SI stated in the interviews arising from one of the five themes of interdependencies between densification and CA: 1) UHIE, heat drought, 2) Water, floods and rainfall, 3) Mobility, 4) Heating and cooling, and 5) Electricity and energy sources and grid.

STATED INTV	**electricity and energy sources and grid**		**heating and cooling**		**mobility**		**UHIE, heat, drought**		**WATER, flood and rain**	
SI	**absolute**	**share**	**absolute**	**share**	**absolute**	**share**	**absolute**	**share**	**absolute**	**share**
Community	2	7,69%	5	16,67%	4	6,78%	0	0,00%	1	3,70%
Culture	1	3,85%	0	0,00%	1	1,69%	0	0,00%	0	0,00%
Economic relations	4	15,38%	6	20,00%	11	18,64%	3	14,29%	9	33,33%
Gender	0	0,00%	0	0,00%	2	3,39%	0	0,00%	0	0,00%
Health	8	30,77%	6	20,00%	17	28,81%	10	47,62%	6	22,22%
Institutional	6	23,08%	4	13,33%	5	8,47%	0	0,00%	1	3,70%
Livability	5	19,23%	9	30,00%	19	32,20%	8	38,10%	10	37,04%
TOTAL	26	100,00%	30	100,00%	59	100,00%	21	100,00%	27	100,00%

Table 6.5: Overview of the absolute number and share of SI reasoned from the interviews arising from one of the five themes of interdependencies between densification and CA: 1) UHIE, heat drought, 2) Water, floods and rainfall, 3) Mobility, 4) Heating and cooling, and 5) Electricity and energy sources and grid.

REASONED INTVERVIES	**electricity and energy sources and grid**		**heating and cooling**		**mobility**		**UHIE, heat, drought**		**WATER, flood and rain**	
SI	**absolute**	**share**	**absolute**	**share**	**absolute**	**share**	**absolute**	**share**	**absolute**	**share**
Community	3	16,67%	2	16,67%	3	21,43%	5	33,33%	4	36,36%
Culture	0	0,00%	0	0,00%	0	0,00%	0	0,00%	0	0,00%
Economic relations	3	16,67%	2	16,67%	0	0,00%	2	13,33%	2	18,18%
Gender	0	0,00%	0	0,00%	0	0,00%	0	0,00%	0	0,00%
Health	4	22,22%	3	25,00%	6	42,86%	3	20,00%	2	18,18%
Institutional	2	11,11%	2	16,67%	3	21,43%	0	0,00%	0	0,00%
Livability	6	33,33%	3	25,00%	2	14,29%	5	33,33%	3	27,27%
TOTAL	18	100	12	100	14	100	15	100	11	100

6.3.2. Results on the individual social impact level

On the level of individual social impacts, Table 6.6 shows the most frequently identified stated individual social impacts perceived by the interviewees in connection to the five themes. In the top row I give the number of quotations per theme. In the case of more than 30 quotations in the respective theme, only the most frequently mentioned are included. Table 6.7 provides the main impacts additionally identified via reasoning in the interviews. The number of instances the social impact was labelled is given in "(...)".

Exemplary, the most frequently stated impact in the interviews in the themes was the **access to public services** followed by **autonomy** impacts, both in the mobility theme. This theme included the majority of stated impacts. Apart from heating and cooling, **actual health** was represented in the most prevalent individual social impacts of each theme. This lasts for **well-being** except in the electricity and energy sources and grid theme. The interviewees referred to **participation in decision-making** particularly in the heating and cooling and electricity and energy sources and grid interdependencies. The interviewees frequently stated impacts in relation to the perception or experience of social inequalities, such as **formation of interest groups due to feelings about interventions** in the electricity and energy sources and grid theme, **government workload and viability** in the mobility theme, **annoyance, dissatisfaction and outrage,** in the UHIE and **social quality and differentiation**.

Again, the variety of impacts in the most prevalent impacts per theme was larger in the impacts that I drew from reasoning also in the case for the interviews. **Housing quality, autonomy, notions about impact equity and fairness** and **social differentiation** counted to the impacts prevalent in this observation.

Table 6.6: Prevalent individual social impacts per theme stated in the interviews (ranked by frequency). The total stated number of quotations in this theme is given in the top row.

electricity and energy sources and grid Top 22 out of 34 quotations	**heating and cooling Top 27 out of 43 quotations**	**mobility Top 44 out of 81 quotations**	**UHIE, heat, drought 27 quotations**	**WATER, flood and rain Top 22 out of 32 quotations**
participation decisionmaking (5)	housing quality (6)	access public services (9)	actual health (6)	actual health (4)
actual health (4)	social differentiation (5)	autonomy (8)	well-being (6)	income (3)
feelings interest groups (3)	living standard (4)	actual health (6)	leisure & recreation (3)	leisure & recreation (3)
econ dependency & vulnerability (2)	participation decisionmaking (4)	physical infrastructure (5)	actual quality (2)	living standard (3)
living standard (2)	physical infrastructure (4)	actual quality (4)	physical infrastructure (2)	well being (3)
physical infra (2)	well-being (4)	govt workload/viability (4)	access public services (1)	physical infrastructure (2)
routine disruption (2)		social quality (4)	annoyance, dissatisfaction, outrage (1)	property value (2)
social differentiation (2)		well-being (4)	econ dependency & vulnerability (1)	actual safety (2)
			envtl amenty value (1)	
			housing quality (1)	
			income (1)	
			routine disruption (1)	
			social quality (1)	

Table 6.7: Prevalent individual social impacts per theme reasoned from the interviews (ranked by frequency). The total stated number of quotations in this theme is given in the top row.

electricity and energy sources and grid 22 quotations	**heating and cooling 15 quotations**	**mobility 17 quotations**	**UHIE, heat, drought 21 quotations**	**WATER, flood and rain 14 quotations**
housing quality (4)	housing quality (3)	autonomy (4)	social differentiation (5)	social differentiation (4)
autonomy (2)	autonomy (2)	impact equity & fairness notions (3)	living standard (2)	actual health (1)
impact equity & fairness notions (2)	impact equity & fairness notions (2)	actual health (2)	access public services (1)	actual quality (1)
income (2)	social differentiation (2)	social differentiation (2)	actual health (1)	actual safety (1)
social differentiation (2)	actual quality (1)	actual quality (1)	actual quality (1)	annoyance dissatisfaction outrage (1)
actual quality (1)	housing availability (1)	annoyance dissatisfaction outrage (1)	actual safety (1)	housing quality (1)
actual safety (1)	income (1)	physical infrastructure (1)	annoyance, dissatisfaction, outrage (1)	living standard (1)
housing availability (1)	living standard (1)	social network disruption (1)	autonomy (1)	property value (1)
living standard (1)	physical infrastructure (1)	social tension violence (1)	envtl amenty value (1)	social quality (1)
physical infrastructure (1)	well-being (1)	well-being (1)	housing quality (1)	social tension violence (1)
routine disruption (1)			property value (1)	well-being (1)
social network disruption (1)			social quality (1)	
social tension violence (1)			social tension violence(1)	
stigmatisation (1)			well-being (1)	
well being (1)				

6.4. General perception of densification in times of CA

Densification attractions

The interview participants identified densification developments often as opportunities to also implement other transitions in the built environment. As G stated, "It's always easier if you make something new, because you start with a clean sheet so you can take all the measures you want. [Densification] gives opportunities for climate adaptation. It is really difficult [to establish transformations in the fabric of] the existing city. [...] Especially if you build a new building, you can make it more climate adaptive" C.4.4. K and D had a similar reasoning. K mentions that the inclusion of nature-based solutions would be the "ideal situation", while D referred to the opportunity to include "small gardens in front of people's doors. You can talk about greening roads [...], walls, small patches" C.4.1. Also participant I sees the densification developments as an opportunity for CCM, as an approach to "becoming more resilient to CC on a micro level", which was in the case of heat adaptation one of the factors now incorporated into the densification plans (C.4.6, 24). To accommodate heat mitigation into urban planning was described as a relatively new policy, which until recently had not been prominent on the national agenda (C.4.6, ID 25).
In their statement, K adds that the inclusion of CCA measures "not only has a positive impact for the people that live in this specific area, but also for people who live in the surroundings" C.4.8. Lastly, H also stated the feedback impact that increased CCA may lead to: "If you improve CCA it will attract people. So you automatically will have [population] densification happening in the city concerned" C.4.5.

Government viability

The participants emphasised that municipal action required a threshold number of residents to be viable. Interview participants J, E and H raised the fact that through densification, the transport system's economic and spatial viability may be increased (C.4.2, ID 6). H related this to the increased population count in particular whereas participant E emphasised that proximity in the dense environment may shorten the distances in contrast to least dense areas, where cars may be the mobility mode of choice if possible. Participant J draws the link also to other public services next to transport, such as a community center, and the social domain in general: "Low density means less people [which would be less] people that make a [public transport] stop or a community center or something like this viable. [...] People make them [the services of the social domain] viable" (C.4.7, ID 3).

6.4.1. Emerging interface issues for this case

In the conversations with the interviewees, I could discern that four issues recurred when the participants spoke about their perception of social impacts at the interface of the two CA transitions and densification in Amsterdam: the competition for physical space in the built environment, property ownership, human behaviour (of residents), and socio-demographic urban inequality, Figure 6.7.

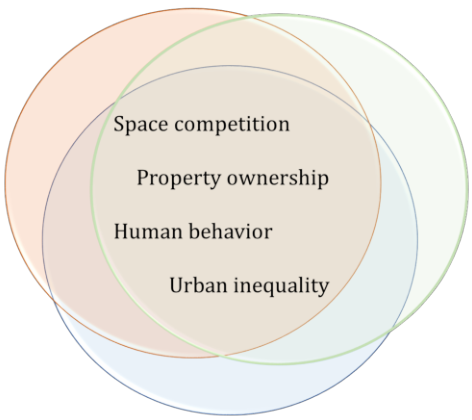


Figure 6.7: In the interviews, four recurring issues were mentioned at the interface of CCA, the ET and densification: the competition for physical space in the built environment, property ownership, human behaviour (of residents), and socio-demographic urban inequality.

Space competition

The competition for space for the functions in the urban space was mentioned frequently (24 quotations) by the respondents. The statement of participant D is examplary for this conflict:

"That's of course a big question of densification in general: It gets more and more difficult to fit everything in. Including trees and underground things...everything actually."
(C.4.1, ID 8)

Participant J identifies a strong demand of space in the provision of sport and park areas, which "don't cost a lot of money, to make, but they cost land. And the land could be used for something else. So that's the competition between a few hundred houses and a soccer field" (C.4.7, ID 26). Following this notion but adding the maintenance costs of green space, respondent F raises the nature of densification as a mitigation tool, that worked if the created levels in the urban space are seen as areas where vegetation can be placed (C.4.3, ID 21).
As space is necessary for housing and green, which leads to a conflict in space, K summarises this as a question of planning for whom and how: "But for example it's not the only question to figure out how to distribute space but also how do we want to live in a densified city? We don't need to look only at the form, but also at the content of what, what are we doing for whom and how?" (C.4.8, ID 1). For instance, the respondent named the example of nature-inclusive architecture: "not everyone is a friend of nature-inclusive architecture. [...] For example, you have bats in , your facades or birds which make noises. They have positive impacts, eating all the mosquitoes for examples. [...] but you have to be aware that the birds also live in your house and you have to accept that" (C.4.8, ID 13). The respondent also highlights the ecosystem impacts of nature-based solutions and potential downsides: " overall I think [nature-inclusive architecture] has a big effect on what we don't really see, but what we nevertheless feel. Because if the biodiversity is healthy in a system, then also the green areas are healthy" (C.4.8, ID 13).
Green areas as a tool to prevent UHIE and to accommodate water surpluses require space. The respondent criticised the fact that including green space into the urban fabric faces the difficulty that the social impact of green space, such as the impacts for well-being of inhabitants in daily life, are not monetised (C.4.8, ID 7, ID 18):

We densify the city and at the same time, simultaneously, we need more space for natural solutions to take a look at all the heat stress drought, water surplus. And Space in the city is so costly and also so profitable. Whether you decide to create a park or a green area or a building that is, but it also has great impact on the well-being of inhabitants. Which is not monetised."
(C.4.8, ID 18)

Ownership

"[I]s that for the lucky few or how are we making sure that the people in the social housing that have less to say about their own houses because the corporations are building them... How are we doing that? How are we making sure that they're part of the process and also have an incentive to participate or feel part of ownership."
(C.4.7, ID 21).

Ownership considerations drive densification development tenders, the installation of renewable energy sources in VVEs or inability to do so by tenants. About 50 % of the public space is owned by the municipality - the remainder by other actors, such as private investors, developers or present or future house owners. The distribution of preventative roles is necessary in the wake of the challenges of CCA investment and limited governmental capacity (C.4.4, ID 15). This multi-actor CA capacity was added by respondent I. At the example of solar energy they depicted that the outcome of CA depended on the standard of living and wealth of the owners and their ability to make investments (C.4.6, ID 4). For participant K, CA measures such as greening and maintenance of green space also should be the responsibility of developers. Ownership is here one of the critical factors next to space and monetary costs. For parallel CCA and densification, the enforce-ability of interventions on developer plots lies not in the hands of the municipality and is complicated even more so where plots are sold to third parties (C.4.8, ID 21). The ownership circumstances in the urban built environment require adjusted processes. Where a building is owned by a VVE, the participant's work included training for the VVE to facilitate decision-making processes on the ET (C.4.6, ID 8). The exclusion from participation in decision-making was stressed as an issue. The ownership of energy production communities may lead to a feeling of participation in the energy transition and increase community cohesion. But, the inclusion of residents in social housing and low.income owners may lack behind (C.4.7, ID 21). This could propagate feelings of exclusion in society and from CA. The impact that densification can have for a positive outcome of CA may be determined also by the setup of housing or mobility modes. Next to the materials used, the resource use depends on the definition of private housing unit sizes and public space, the incorporation of shared or privately used space. The mode of mobility also highly impacts the use of public space. In connection to the ET and mobility transition, densification could thereby be a tool to facilitate shared and high accessibility mobility modes and amenities (C.4.8, ID 15, 26; C.4.2, ID 12). Finally, as presented in Section 7.3.2, the consequences of CC and CA might affect property values - and, in this way indirectly imply advantages and disadvantages of ownership.

Human behaviour

How do densification and CA interact with human behaviour? The interviewees stated the importance of human behaviour in seven instances. Participant G speaks of densification as an enabler of the ET, in the form of shared mobility concepts. Additionally, they identify densification with an opportunity to reduce the use of resources by multi-functionality, smaller housing unit sizes, the incorporation of secondhand stations. But, this the respondent states will depend on the package of measures as much as on human consumption behaviour (C.4.4, ID 23). Participant I shows a similar perception of the circularity potential of densification. As the population increase through densification will also increase material flows, material use reduction and recycling could be promoted in the housing construction. But, a crucial factor is the human behaviour, which at the moment of the interview, they identified as a consumerist society (C.4.6, ID 26). Finally, respondent D stresses the non-linearity of a correlation between densification and a circular economy: "The most obvious result is in mobility, of course. Walking is more circular and leads to more health. That's quite obvious. [...] Densified areas contain smaller houses on average than suburban areas. So the use of material per person will reduce, it will be more circular as well. [...] [I]f you share cars or laundry machines, that also saves energy and resources. [But] [...]it is not about labels [such as low energy consumption of buildings], it is about absolute consumption" (C.4.1, ID 18). While an example of the increased resource use in urbanised, highly populated areas in absolute numbers, this understanding also highlights the necessity of human behaviour changes and adaptation in CA despite alleviating effects of densification. As mentioned above, the ET and densification have implications for human behaviour on the basis of daily routines. The use of electric devices might have to be aligned with electricity generation and grid capacities. As energy prices rise and housing qualities differ, K also adds that societal inequality also exists in the consumption and production of energy, affecting mental and physical health (C.4.8, ID 6). Thereby, densification in relation to the improvement of the building energy performance might be a tool to alleviate more equality in human behaviour. Lastly, D connected the shifting mobility patterns in the densified areas and the spill-over effects into surrounding areas and concluded a slow spread of the aimed for more sustainable mobility behaviours of walking, cycling and public transportation use based on proximity to the adjacent areas (C.4.1, ID 13). Thereby, densification in one area might also be a tool to decrease social differentiation in surrounding areas as for the accessibility, availability and affordability of these mobility patterns.

Urban inequality

Urban inequality was approached from several sides in the interviews. The understanding as such was based on the social impact understanding and intersectionality as presented in Chapter 3. Urban inequalities were reflected in perceptions of distrust in governmental institutions due to experiences and notions of difficulties discrimination and stigmatisation by socio-economic and demographic groups. The example of low-income households was given. These were pressured by daily requirements and impossibilities of investments. In relation to CCA or the ET, even where inaction might lead to even higher costs, the locked-in social situation may be hindering CA (C.4.6, ID 22). Gentrification due to densification and CA transitions in the built environment were another social impact feared by several of the interviewees. They urged for caution if the developments had a negative outcome, if accompanying policies and tools cannot prevent a stratification and separation of socio-economic and demographic groups in short or long-term observations (e.g. in connection to housing: C.4.7, ID; in connection to mobility C.4.1, ID 12, in connection to employment options: C.4.7, ID 17; C.4.2, ID 15). The urban inequality founded on the city's development and topography recurred in the observation of flood risk and vulnerable populations (see Section 7.3.2). Inequality in the participation in decision-making was another recurring facet. Participation or exclusion from energy communities, VVEs, smart or low-cost energy systems or participation in the planning of the densification elements (C.4.7, ID 14) were areas named by the interviewees.

6.4.2. Knowledge silos/gaps in policymaking stated by participants

In this section, I present the potential for accompanying policies or tools, areas of knowledge silos and future research hints that the participants stated. These prevent insights into the context of the case and potential implications for future policies and research.

Planning department silos

The interdependency of the CA transitions and densification is not on the agenda for every department. Whereas the CCA coordinator G had not yet looked at the relationship between densification and CCA, they assumed that colleagues from the spatial planning and sustainability department had done so (follow-up communication on C.4.4, ID 7). To communicate the information presently available in the departments of the municipality within and to external actors stated necessary to take the best measures possible (C.4.4, ID 15). Participant J pointed out that the spatial development department in charge of housing and the department in charge of planning physical space for the social domain are not the same. A consequence is that the social domain needs to be incorporated into budgeting and planning separately from housing (C.4.7, ID 1). J elaborates on the inclusion of amenities in the development. They state that only certain amenities are included in the "Referentienorm". Services and functions that are not listed in this policy, may fall through the net as the department is not particularly responsible for their inclusion (C.4.7, ID 2). As other departments are responsible for the planning and incorporation of these excluded services, this issue is one of the knowledge silos in policymaking practice.

Emerging tasks and skills in policymaking

K and F reflected on the recently emerged subject of the underground space effects of spatial development and densification. As the impacts on the soil through, for instance, the addition of sand during construction changes the composition of the substrate, the impacts on the ecosystem and CCA are yet to be explored and acknowledged (C.4.8, ID 11; follow-up on C.4.3). But, K also emphasises that the spatial planning departments are working on the improvement of their skills to make more and better public space, to accommodate spatial restrictions of parallel functions (C.4.8, ID 22).

Staff diversity in policymaking

Additionally, the non-representative perception of an increased female share in nature-inclusive architecture for an amplified inclusion of nature-based solutions for CCA in densification was mentioned by the participant (C.4.8, ID 24). Participant H expressed the notion that the planning and policymaking practice body is not yet as diverse as they experienced scholarship and education to be. They stressed that "where you are coming from will aslo impact the subjects that you want to work in, that you are interested in. [...] For sure, you are more interested in the social relevance when you have your own personal experience and something to say about it now" (C.4.5, ID 4). Moreover, participant F emphasises that residents and the public should be included as much as possible into planning to also acquire experiential knowledge of residents and to make the decision-making process as transparent as possible (C.4.3, ID 7).

6.4.3. Accompanying policies and tools suggested by participants

Amenities, employment options and mobility

Participant J raised the evident connection that to establish proximity and walkability in the densified city, the amenities and public transportation services have to be in place (C.4.7, ID 27). To prevent the disruption of social infrastructures if residents have to move due to densification developments, the respondent voices the concern that the solution to this gentrification phenomenon has not been found yet. The current accompanying policy is to "provide affordable places and stores and community centers that keep the social infrastructure intact" (C.4.7, ID 5).

To improve the inclusion of a variety of occupational opportunities into the densification design to prevent social differentiation was mentioned by several interviewees. As there is competition amongst municipalities for social welfare employees in dense areas, E gives the example of free parking permits handed out to teachers. Another policy measure it to allow social welfare employees a first right to apply for lower-rent housing units (C.4.2, ID 14 to ID 17).

Rents

For residents that lived in social housing, in particular housing with lower energy performance levels, the right of return policy can be applied. The former residents may get the guarantee that they can return to the same neighbourhood. However, the rent price will not be the same. Therefore the housing quality and standard of living may increase, but the rent as well (C.4.7, ID 6).

Spillover in planning

To broaden the benefits created through densification and to buffer the adverse impacts for adjacent neighbourhoods, J suggest the inclusion of these into the budgeting process. Another option is to include facilities and social services in the densifying areas that might attract and have the necessary capacity to support residents from surrounding neighbourhoods (C.4.7, ID 8).

Circularity of construction materials

Participant K expresses the need to look at existing building materials in place and to create adaptable designs to prevent energy performance issues and high prices for residents in the coming years. In the consideration of not only CCA and the ET relationship with densification, but also the accommodation of higher circularity in resource use as CA, K ponders on the options to include policies on construction material re-use, or locally sourced bio-based insulation material. At the hand of these examples, the respondent urges for the adaptation of policies to the materials and build environment in place instead of vice versa (C.4.8, ID 17, ID 28). Additionally, F raises the enabler function that material passports can have for a more circular resource use in the densification process (C.4.3, ID 19).

Indices and mapping

The measurement of benefits of green spaces for residents has been criticised by J in the same way as by participant K. They expressed the lack of an index to measure social benefits just as monetised / financially measurable housing unit measurements (C.4.7, ID 24; C.4.8, ID 18). Likewise to the measurement of impacts, respondent H raises the advantages that emerging communication technology such as neighbourhood applications or maps may bring. These could be used also to provide data to research (C.4.5, ID 13).

External actors and communication

Finally, participant F expresses the overarching feature of cities as an aggregate of a multitude of actors. For this reason, the municipality is not the only player. The aversion of adverse social impacts in CA and densification developments is not for certain something that the municipality can prevent (C.4.3, ID 16). As F mentioned the variety of actors in terms of the policy- and agenda setting influence potential, G stresses the importance to communicate the climate risks within municipal departments and towards the public. As the municipality alone will not be able to provide preventive or adaptive measures to everyone, it will be indispensable that private owners of land and housing take steps (C.4.4, ID 15).

Chapter 7

Divergence and Overlap of the Perspectives

In this chapter I will take a comparative look at the results of the two main methods. In Section 7.1 I will do this on the level of SI in the data sets, in Section 7.2 for the themes on the same level. How individual social impacts manifest in the interdependency themes I illustrate at the hand of selected individual social impacts and quotation examples from the two perspectives in Section 7.3. The full exemplary quotations for the themes UHIE to heating and cooling are included in Appendix E. I close this chapter with an overview of contextual factors in Section 7.3.6.

7.1. Overall SI frequencies in both perspectives

Looking at both method strains, the stated SI occur in almost the same order, with the exception of health being more commonly named than economic relations in literature than in the interviews and vice versa, see Figure 7.1. In this regard, the interview participants also differ from the findings of the knowledge base even when they are reduced to the expectations. Also by means of the reduction of the SI stated in literature to the case study regions, health impacts would be the second most stated impacts. In the remainder of the ranking however both strains overlap: I identified livability impacts with strong prevalence of at least 31 % or more. Community impacts ranged between 11 % to 14 % of the stated impacts. Institutional impacts ranged between 7 % to 10 % of the identified impacts while they were more frequently mentioned by the interviewees than in literature. The same stronger attention was given to community impacts. Culture and gender impacts never made up more than 3 % of the identified impacts.

Comparing the stated impacts with the impacts that I additionally reasoned as implicitly embedded in the collected data, social trade-offs become apparent: I could derive impacts on health as the prevalent impacts, instead of livability impacts, see Figure 7.2. This was true for both data sets, even though to a larger extend in the case of the interviews. This shows that there are trade-offs for health due to densification in times of climate action which are not directly addressed, but which can be discerned from current research as well as the perceptions of policymakers.

Moreover, I could filter 20 % of community impacts through reasoning in the literature review data to almost half of this, 11 %, of community impacts stated. Also within the data collected from interviews, the implicit mentioning of community impacts amounted to 21 & in contrast to the explicitly stated 14 %. Institutional impacts I observed as implicitly embedded at a share more than twice as large in the perceptions of the interviewees. Considering their professional and experiential background as urban planners in a public, municipal institution, it is not surprising that the participants refer to institutional impacts implicitly. In the literature review data, I did not reason implicit institutional impacts more often than they were stated.

The observation of cultural impacts seemed to be almost insignificant looking at the absolute values. In particular in regard to the statements made in the interviews, the participants themselves stated cultural impacts at a higher frequency than which I could reason in addition to their comments. This may be due to my limited conceptualisation of culture relations impacts in the urban sphere in Chapter 3.

In the case of gender relations impacts, I reasoned them at a higher share than at which they were stated in both data sets. This shows that looking at the existing data from a new angle might shed stronger light on gender focused social trade-offs of densification, CCA and the ET.

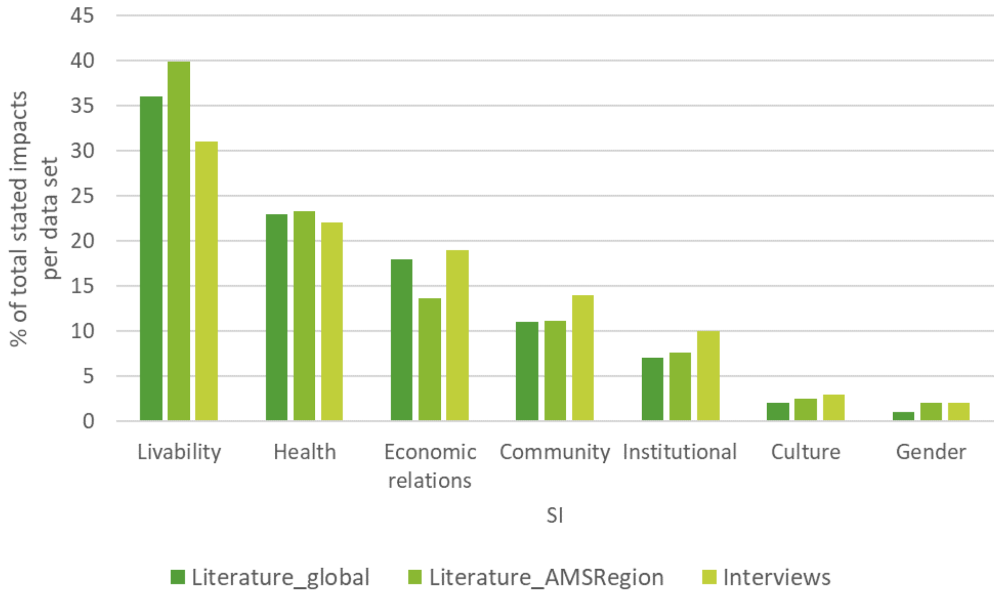


Figure 7.1: The final distribution of identified explicitly stated social impacts per SI and data set: the overall literature review, n = 91, the literature review reduced to the "AMS-region", n = 45, and the interviews with the urban policymakers in Amsterdam, n = 9. The values are the share in % of the SI out of all seven SI per data set. 100 % = impacts labelled in all seven SI per data set.

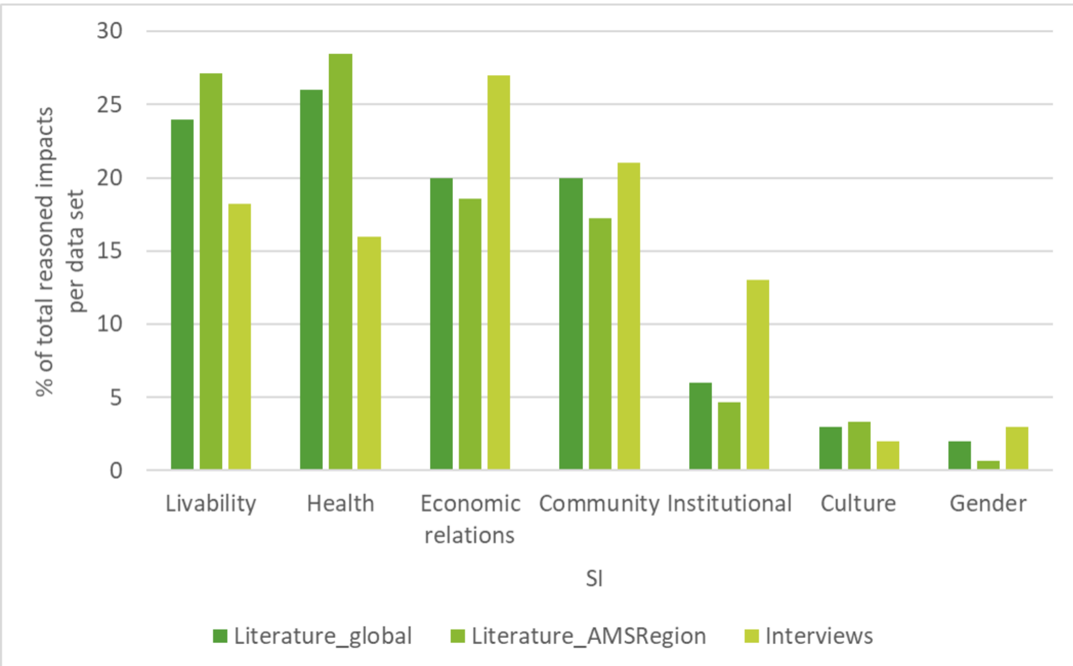


Figure 7.2: The final distribution of identified implicit and reasoned social impacts per SI and data set: the overall literature review, n = 91, the literature review reduced to the "AMS-region", n = 45, and the interviews with the urban policymakers in Amsterdam, n = 9. The values are the share in % of the SI out of all seven SI per data set. 100 % = impacts labelled in all seven SI per data set.

7.2. SI in the interdependency themes in both perspectives

In the literature review, the most prevalent theme connected to SI was UHIE, heat and drought, whether the impacts were stated or reasoned. Looking at the number of search results, this is exceptional, as the number of papers connected to CCA and the ET were relatively equal. In the interviews, the prevalent themes were ET themes, with mobility making up for the most of stated impacts. This may give an indication of the CA and densification perception of the interview participants as well as the policy focus on these themes in Amsterdam.
Amongst the impacts that I reasoned from the statements of the participants, this imbalance was less compelling. However, factors reasoned in regard to electricity and energy sources and grid were still the strongest.
Gender impacts were only stated by the interview participants in relation to mobility and no implicit impacts on gender relations were given. In the literature, no gender impacts were stated in connection to any of the five selected themes. The gender impacts discerned from the literature were mention in reference to spheres outside these five themes. In two instances I however reasoned gender impacts as implicit in the themes of heating and cooling and mobility.
Furthermore, I reasoned cultural impacts three times in contrast to one times they were stated in the mobility theme. In the interviews, culture impacts were mentioned in two instances. I did not reason any additional impacts for this SI in the themes, this overlaps with the overall low number of cultural impacts.

Between the stated SI counts in the global and the literature review data set reduced to the AMS-region health, livability and economic relations were the highest ranking SI in the impacts stated in connection to all themes. In the SI that I reasoned, this changed in particular in the mobility interdependency. Here, I added a strong reasoning of community impacts in the global literature set, which was not prevalent in the AMS-region. While livability impacts were also high ranking in the interviews, the stated impacts focused less on economic relations. In the observation of reasoned impacts I could depict a divergence in particular for the mobility and energy sources and grid themes where the institutional SI was the second most prevalent after the health SI.

7.3. Zooming into the interdependency themes - individual social impacts and illustrating examples

In this section I will compare the two perspective's view of social impacts in the interdependency themes. Each section start with a general overview of the prevalent stated and reasoned SI and then summarises the main points of the theme and the most prevalent individual social impacts. Then, I provide representative examples from the two data sets for each theme. The remaining examples can be consulted in Appendix E.

7.3.1. UHIE, heat, drought

Overview

The strong SIs livability and health are reflected in the overlapping most prevalent particular social impacts, see Figure 7.3. This also does not change in the reduction to the AMS-region in literature and holds for the reasoned impacts, Figure 7.4. However, in my reasoning from the interview perceptions, impacts in the community SI were frequent.
Actual health and well-being as well as actual quality of housing, the adequacy of the physical infrastructure and leisure and recreation impacts are prevalent. In addition, impacts on the value of environmental amenities and social quality appear. Figure 7.5 shows the theme factors discerned from the analysis of the two perspectives.

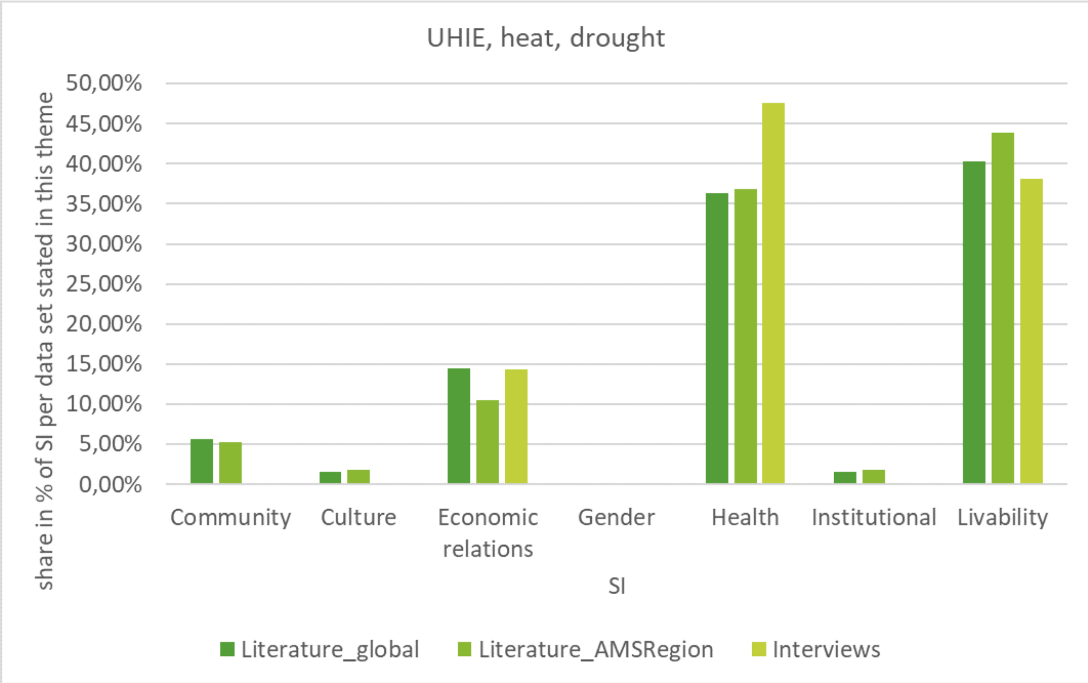


Figure 7.3: Distribution of SI % per each of the three data sets labelled as stated in the theme of the UHIE, heat and drought.

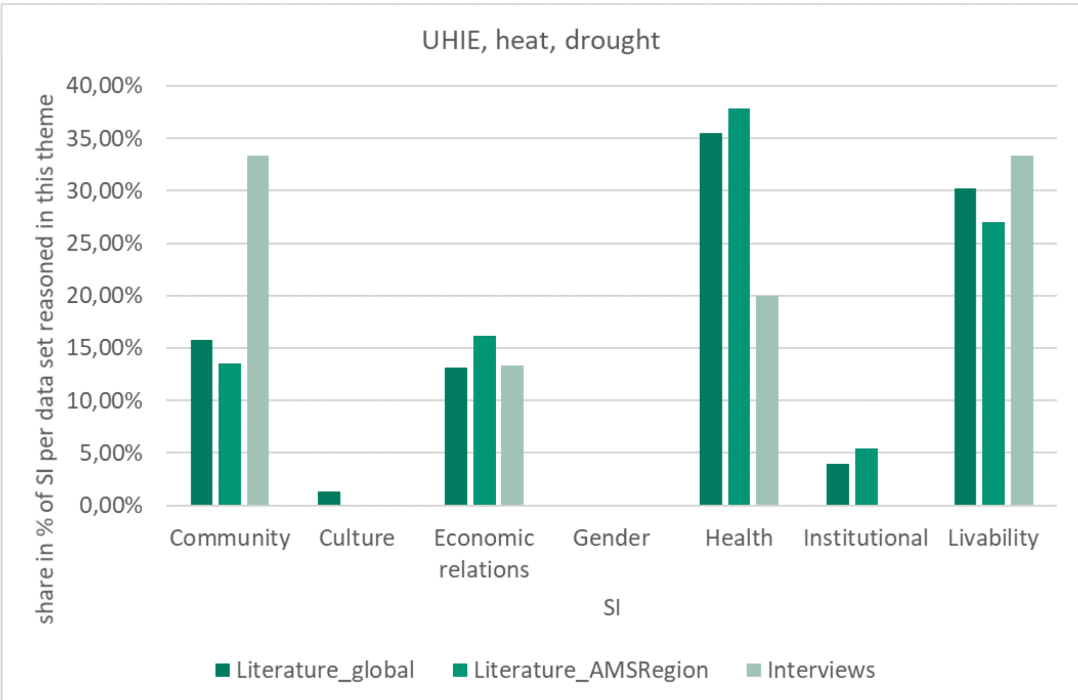


Figure 7.4: Distribution of SI % per each of the three data sets labelled as additionally reasoned in the theme of the UHIE, heat and drought.

Moreover, both literature and the interviews asked with relation to green space: **Who has access, who owns an who can use this space?** This relates to the effect that the change of urban form had on the thermal comfort of the users of urban space: residents, or other individuals using the public space. Both perspectives identify the need for cooling, for cool leisure areas. The inclusion of green space was

opted for by literature and interviews, to prevent a diminishing effect of the value of environmental amenities and increase the adequacy of the physical infrastructure for physical and mental health of individuals using urban space.
In the social impacts that I could reason from the data, one additional aspect became apparent making use of the reviewed literature in Chapters 3 and 5: The potential impact of the physical change in the UHIE interdependence on social differentiation. This means, scholars' and planners' might implicitly perceive the potential of densification in times of climate action much stronger than explicitly stated.

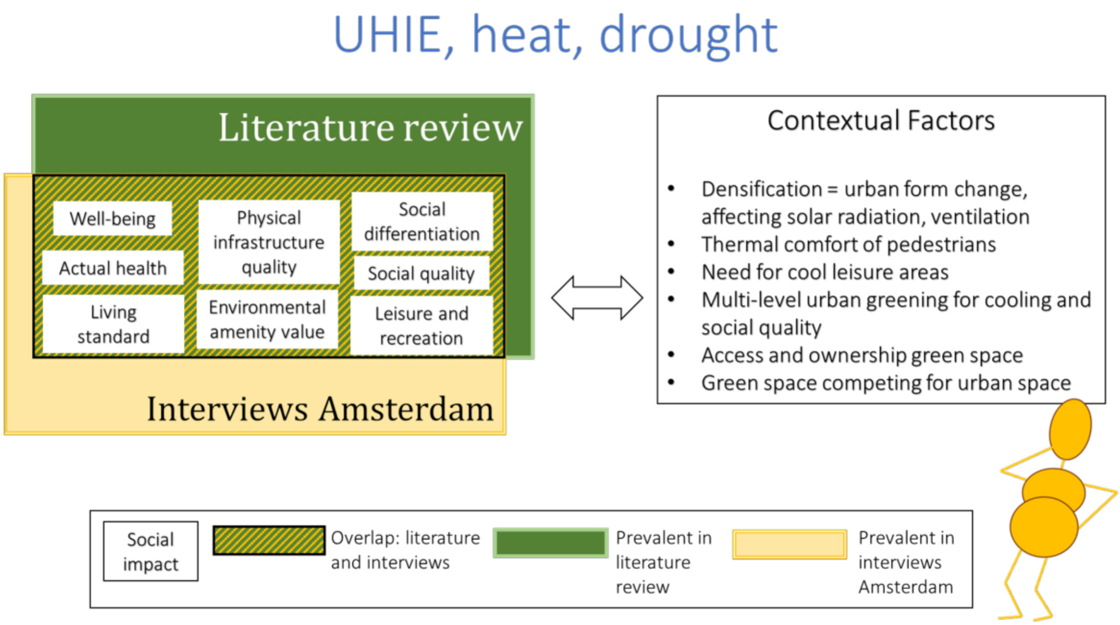


Figure 7.5: Prevalent individual social impacts and contextual factors discerned from the two perspectives in the UHIE theme.

UHIE, heat and drought examples

In the theme, the perspectives referred to three groups of social impacts most prevalent, **1) Well-being and actual health, 2) Physical infrastructure and environmental amenity value (particularly in literature) and 3) Leisure and recreation (particularly in the interviews)**. For the full text version of these examples consider Appendix E.1. Examples from literature are given in turquoise, quotations or paraphrased sections of the interviews in yellow.

Well-being and actual health impacts

Gadish et al. (2023, p.12) found that increased building heights that deepen street canyons might lower the UHIE through the shading that is provided. In their study this effect was shown despite the parallel consequences of smaller wind speeds and increased mid-day air temperature. This affect they connect in particular to the sensation of heat stress by pedestrians.
Additionally, Erlwein and Pauleit (2021) elaborate, that an open building arrangement, enabling air flows into the built-up block is more effective, than increasing open sky views. In combination with additional shading by increased building heights, this can lower short-wave radiation and improve the residents' thermal comfort.
In the interviews, the complexity of alterations that densification infers on air corridors, ventilation and the resulting thermal quality was for instance discussed by respondent G. Referring to Buikslotersham, a Northern Amsterdam neighbourhood which has been under development from a former harbour and industrial area to an area with a majority of residential use, G states the diverging impact of air corridors, which may be due to building orientation. In hot weather, residents might experience this as refreshing, in cold or windy conditions, residential comfort may be diminished (C.4.4, ID 11).

Physical infrastructure and environmental amenity value impacts
Physical infrastructures often related to green space, its environmental value for actual health and well-being as indirect impacts.
For instance, due to their provision of shading and transpiring cooling, Segura et al. (2022) term street trees as "an important driver of street micro-climate [... and providing] key mechanisms for improving thermal comfort in urban areas" (Segura et al., 2022, p. 1). Reviewing works of the past ten years, the authors discuss the difficulty and variability of modelling the potential of street trees to cool urban street canyons. The trees' cooling effect depends on "the canyon geometry and sun-orientation, the local meteorological conditions, the geographic setting of the city, the amount of tree canopy covering the canyon floor and distribution, tree typology, the water availability for trees and the tree health condition" (Segura et al., 2022, p. 2). The authors also point out, that the effect of street trees differs from the effect of trees in urban parks and green patches, making it necessary to differentiate between studies on trees' effects.
In terms of residents' perceptions, Byrne et al. (2016) reported respondents' high levels of perception of shade provision and temperature reduction as health contribution of trees. Despite a reported impression of disadvantageous maintenance costs of street trees, the authors recommend street trees amongst other forms of urban green infrastructures as policy response to the UHIE.

Leisure and recreation impacts
Participant L raises the social aspect of green space use, identifying a social differentiation in who has the ability to reach recreational areas outside the city. For this reason, green space areas would need to be incorporated into the urban fabric 'in front of your doorstep'. This could provide a more equal access to green space (C.4.9, ID 22).
This aligns with Venter et al. (2023, p. 5) who call for the observation of existing urban inequalities in densification developments. Access to green space and exposure to air pollution and solar radiation in their case study Oslo are correlating with income groups. Densification not accounting for these inequalities may increase adverse CC consequences and should therefore be part of CCA risk plans.

7.3.2. WATER, flood and rain

Overview

The interviewees as well as the literature state similar prevalent social impacts in the Water interdepenedency. The stated SI per perspective in this theme are shown in Figure 7.6.
Prevalent overlapping social impacts comprised **1) impacts on physical infrastructure qualities, 2) economic vulnerability and living standards, and 3) social differentiation** The full text of these examples is included in Appendix E.2.

WATER, flood and rain examples

The interviewed policymakers of the municipality of Amsterdam strongly perceive the economic relations impacts. These are impacts on residents' living standards and the monetary value of urban properties. This was related to topographic and socio-economic specificities of Amsterdam:
Respondents G and F highlighted the criticality of the area choice for densification. Lower-lying areas that are already more susceptible to floods would have an increased vulnerability if additional housing units are build (C.4.4, ID 4; C.4.3, ID 9, ID 12). Participant F mentioned that the lower lying neighbourhoods already faced the need to pump out inundated basements and the consequent damages after extreme rainfall events. For these reasons, the protection levels will have to scaled up if such areas are densified (C.4.3, ID 8, ID 9).
On top of the costs of recovery from extreme events may come these negative property value developments (C.4.3, ID 11, ID 12). This might pose another factor of urban inequality as lower income populations have a geographic and topographic correlation with lower lying areas, and also areas under consideration for densification (C.4.3, ID 13). The participant called for precautionary planning, including dissemination of residents and municipal officials and participation in the planning process to prevent dissatisfaction with the authorities and political institutions (C.4.3, ID 10, ID 12). The vulnerability of electricity infrastructure and electric infrastructure such as data centers in particular in flood prone areas was identified as challenging the planning and physical layout of the grid as certain areas have to be avoided (C.4.4, ID 5). In the built environment, the observation of existing water flow directions and strengths in construction projects is important to not increase flow resistances and current forces. The work of Li

et al. (2021) is relevant in this case. The authors conclude that

> "the conveyance porosity and the number of streets along the direction normal to the main flow offer an opportunity for new developments which do not increase flooding severity." (Li et al., 2021, p. 14)

Moreover, were flow paths already existed, Li et al. (2021, p. 14) call for their maintenance, as "fragmenting a flow path into several ones [...] increases the flow resistance".
Green spaces, such as green roofs, parks and small pocket patches and trees not only have a cooling effect through evapotranspiration but also may provide space for water storage and ground permeability in cases of extreme rainfall. In Rosenberger et al. (2021) green roofs, even though retaining water, may not be able to withstand future CC rainfall scenarios. However, they still have delaying capacities for drainage, making them beneficial CA infrastructures.
The risk of floods and rainfall were discussed in Morelli and Cunha (2021), establishing flood vulnerabilities of various transport modes. The authors conclude that next to building layouts, the development of more resilient transportation can provide added resilience of physical infrastructures during rain events.

In the reasoning from the literature I could as well discern impacts from the interdependency on property values and economic vulnerability in literature see the representation of the SI economic relations in Figure 7.7. In this figure, the community SI was again frequent in the interviews. This was due to the implicit mentioning of social differentiation, compare Table 6.7. The institutional impacts in literature, i.a. arose from identification of impacts on the government workload and viability and participation in decision-making. Finally, the question can be derived **when do monetary costs occur and determined by that, who pays for them?**.

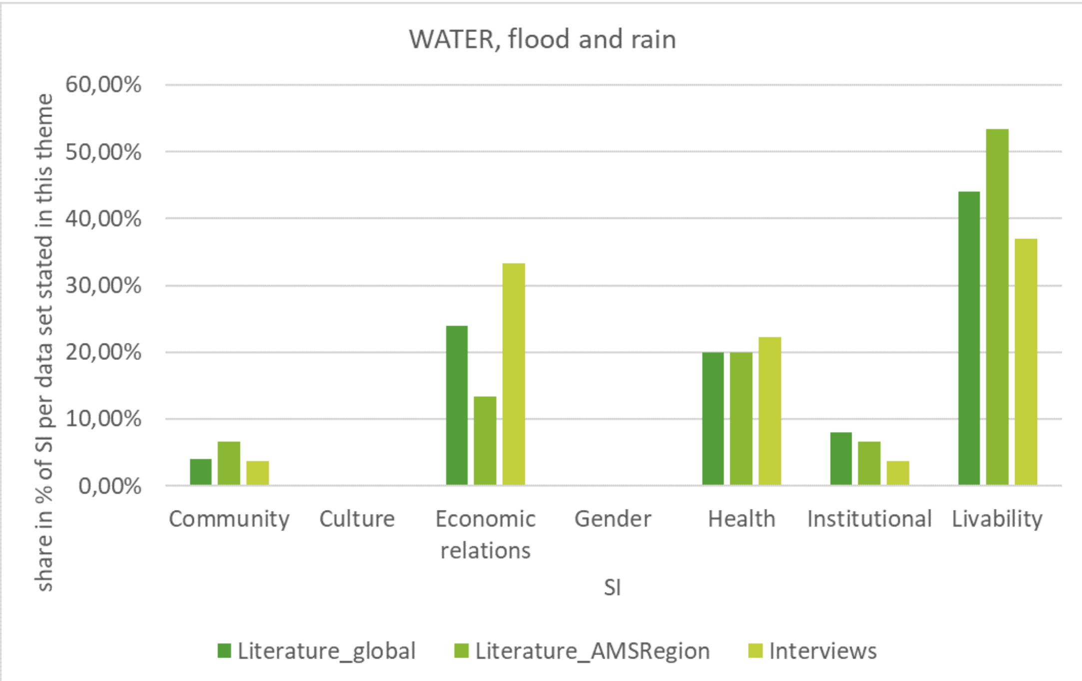


Figure 7.6: Distribution of SI % per each of the three data sets labelled as stated in the theme of Water, flood and rain.

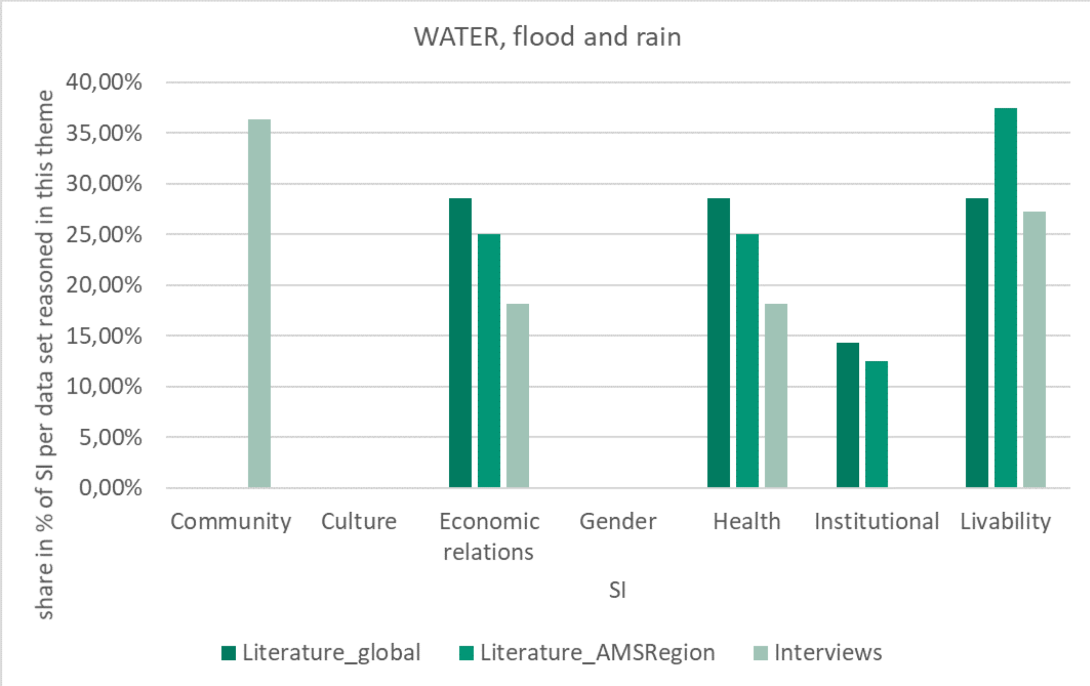


Figure 7.7: Distribution of SI % per each of the three data sets labelled as additionally reasoned in the theme of Water, flood and rain.

The theme factors that I identified in the analysis and the prevalent social impacts of this theme are presented in Figure 7.8.

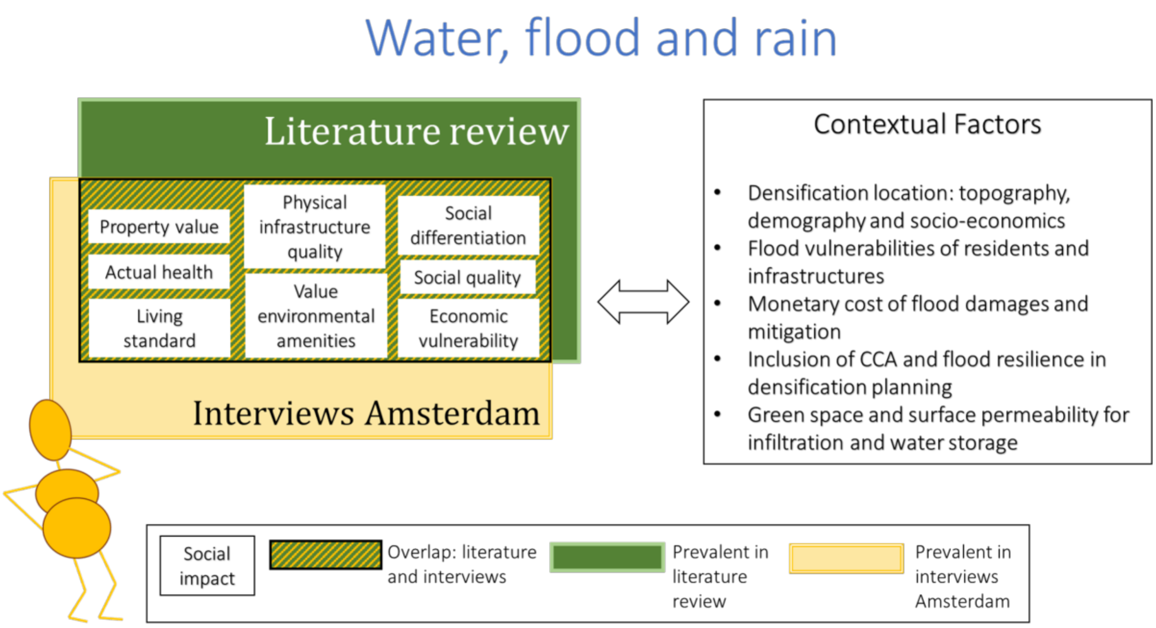


Figure 7.8: Prevalent individual social impacts and contextual factors discerned from the two perspectives in the WATER theme.

7.3.3. Mobility

Overview

The stated SI per perspective in this theme are shown in Figure 7.9. As the strongest SI was **livability** for all themes in both perspectives, this also applies to mobility. The adequacy of infrastructure, the **actual quality of the built environment and the options of walking and cycling** (Morelli & Cunha, 2021; Perera et al., 2023) were frequently mentioned in this interdependency. In particular the interviewees perceived this as a factor positively affecting **actual health and well-being** of residents.
In the literature, the second most prevalent SI is economic relations. This is reflected in impacts on **living standard, income and employment options** as well as the **access to public services**. In terms of percentage, the literature also explicitly mentions **community impacts** at a high frequency. In this regard, the increased population counts due to densification need to be provided with accessible infrastructure. In contrast to this, the policymakers perceived **autonomy** impacts as prevalent next to the **access of public services** in this interdependency.

In the literature as well as in the interviews, I could discern autonomy impacts most prominently in this theme, see Figure 7.10. The interviews also implicitly address impacts changing notions about the intervention's fairness and equity next to social differentiation. This lead to a higher share of institutional impacts. **Who will gain access, to which services? And are infrastructures financed and adaptive?** are strong questions arising from the stated impacts. But, looking at it in detail, the global literature set (Everett et al., 2018; Muñiz & Dominguez, 2020; Muñiz & Rojas, 2019; Vich et al., 2019) can be seen as capturing this in the observation of actual social differentiation impacts.

Figure 7.11 shows the theme factors identified in the analysis and the prevalent social impacts of this theme.

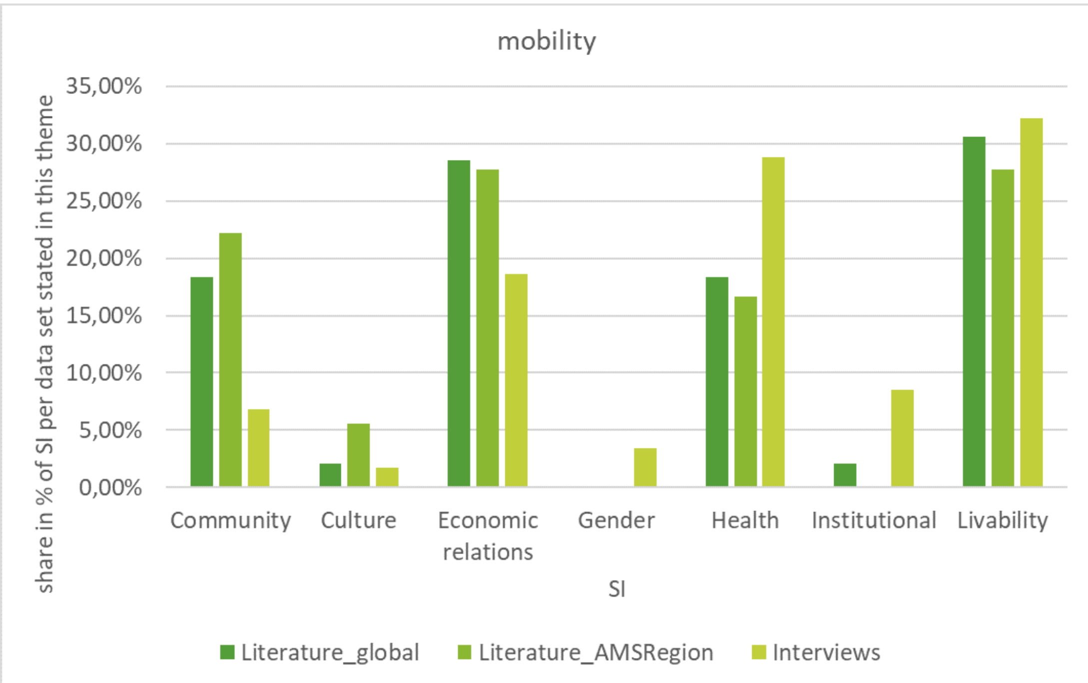


Figure 7.9: Distribution of SI % per each of the three data sets labelled as stated in the theme of mobility.

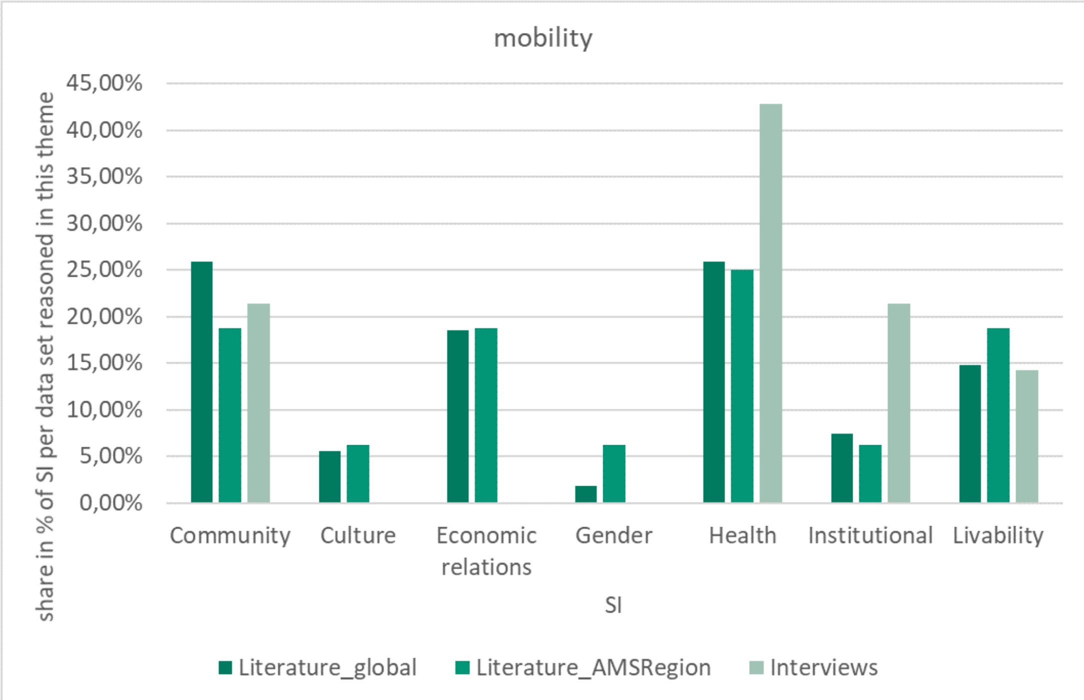


Figure 7.10: Distribution of SI % per each of the three data sets labelled as additionally reasoned in the theme of mobility.

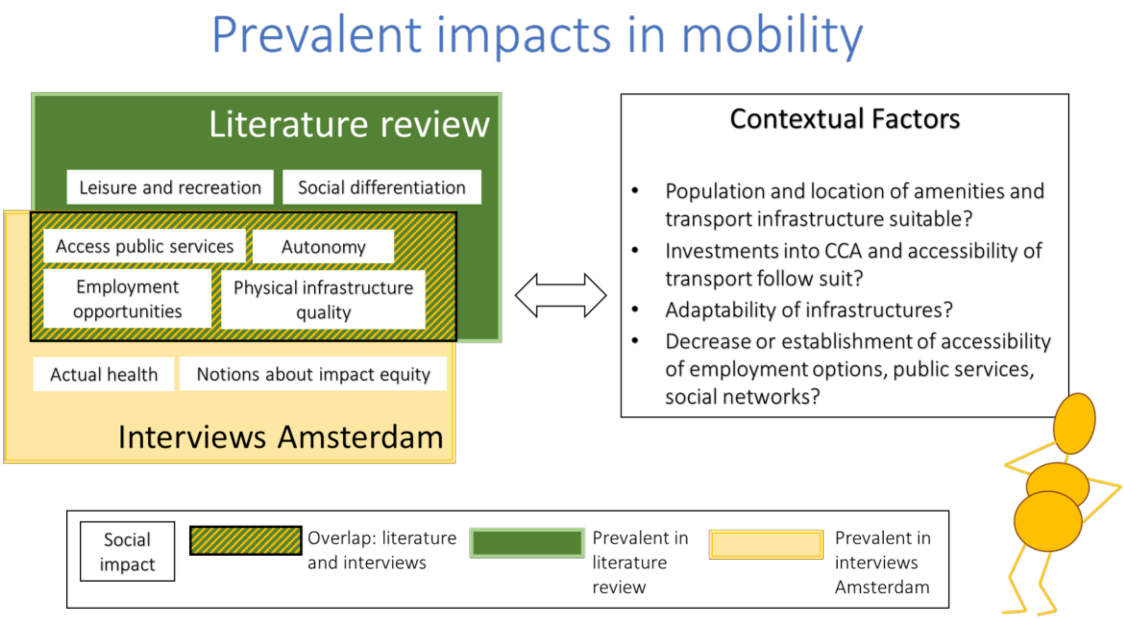


Figure 7.11: Prevalent individual social impacts and contextual factors discerned from the two perspectives in the mobility theme.

Mobility examples

For the full text illustration of these examples, I refer you to Appendix E.3.

Autonomy, social differentiation, access to public services and employment opportunities

The aimed for proximity to amenities would allow for walkability and cycle-ability, which are flexible in their route choices and traffic directions. Also Perera et al. (2023) conclude that topography needs to be considered in densification developments. As walking is a high-accessibility and -availability mode of transport (Vich et al., 2019), densification may disproportionately affect vulnerable groups. Urban areas in particular may lead to social differentiation in mobility, where CC and densification adversely affect outdoor thermal comfort at pedestrian level. Potentially adverse impacts on autonomy may arise from increased heat on surface levels, inhibiting especially cycling and walking, which was discussed by Segura et al. (2022, p. 17) and Palusci et al. (2022, p. 1). Another example is the study by Rosenberger et al. (2021) on sustainable water management during densification and CC. The authors conclude that "[p]orous pavements offer a straightforward possibility to increase the infiltration of areas like footpaths or cycle tracks" (Rosenberger et al., 2021, p. 9). Given proximity aims of densification I reasoned impacts on autonomy.

Participant J points out that this ideal might remain an empty promise, if the houses are being build, but the investments into public transport do not follow. This would lead to the counter-effect of higher resident numbers in areas of low accessibility (follow-up communication on C.4.7, ID 19).

Respondent J further gave the example of a neighbourhood team which had been established in Amsterdam, but which was not accessible to groups with lower mobility capacities as the institution's building did not provide a parking spot for handicapped people, "because we did not have enough parking spaces in that neighbourhood." In this way, social inequalities can propagate as social support to for instance groups of lower mobility cannot be offered properly if the groups that need it cannot reach the established facility (C.4.7, ID 18).

People walk and cycle more and walking and cycling, of course, is a more inclusive way in mobility than cars. And it's a very difficult discussion because this is the theory, but in practise the areas which are suitable for walking and cycling are the most gentrified areas. Which is not inclusive at all. There's quite . . . this is actually quite a paradox.

(C.4.1, ID 12)

Participant K also raises these issues and calls densification "wishful thinking" if it is seen as the solution to [all] societal problems. While it may improve "the access to institutions, to healthcare, [...] or to jobs, so that people can also, with a low income, or without a car, have a job in the neighbourhood", the facilitation requires observation of the impacts. In particular, the respondent emphasised that issues would be strengthened if created job opportunities would not be equally distributed over income groups (C.4.8, ID 25, ID 29).

Autonomy of women - the gender SI

In the interviews, impacts on the autonomy of women were mentioned by the participants which I could not identify explicitly in the literature.

In the conversation with participant H, they used the example of the US-American urbanisation model and the implications for women living in suburbs to underline the equalising effect for women's, children and the elderly's access to public services: "[if] where you live, you can get out of your house without having a car, [...] without being car dependent, that's super important. For women, but also for children, and young people, or for elderly who cannot drive anymore" (C.4.5, ID 11).

That proximity, walkability, close amenities, green space and public space of densification could increase the autonomy of "people that are more at home, not necessarily women [...] but [...] people that are more at home" was also raised as potential benefit of densification by participant K (C.4.8, ID 23). Similarly, participant E perceives densification as potentially relieving pressure from care-work tasks if the functions in the city are brought closer together, are accessible by bike or walkable. This may give room to the institutional side of emancipation of women, who have been the majority of care-workers in the past. A side effect of these means of transport are the benefits for actual health of the residents (C.4.2, ID 24).

7.3.4. Heating and cooling

Overview

The stated SI per perspective in this theme are shown in Figure 7.12, the SI reasoned in Figure 7.13.

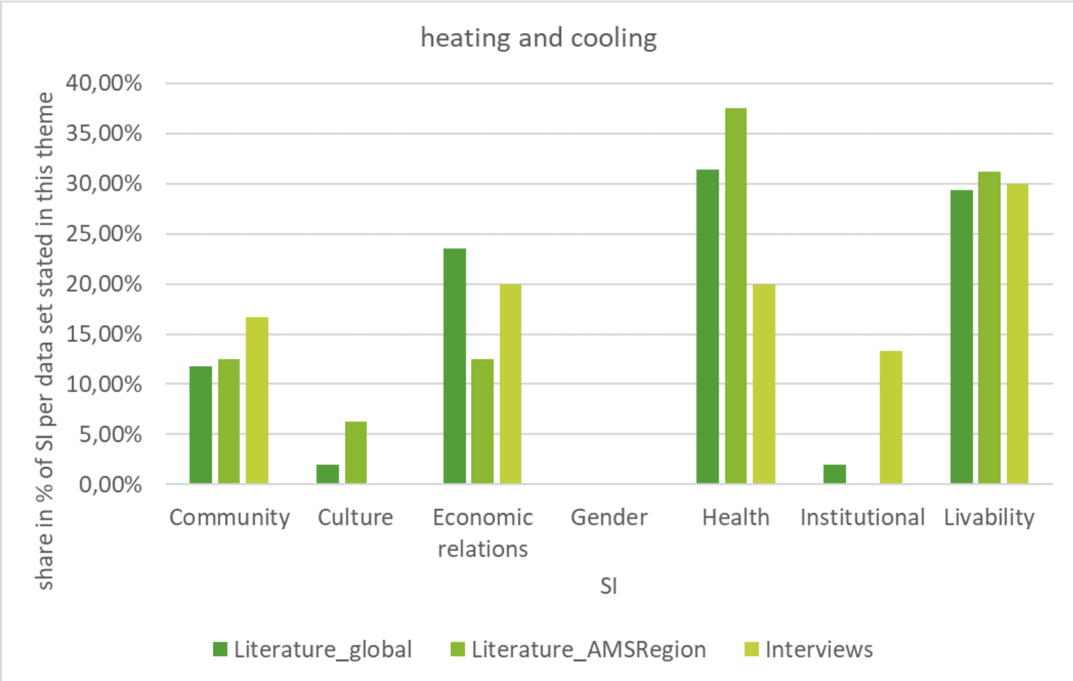


Figure 7.12: Distribution of SI % per each of the three data sets labelled as stated in the theme of heating and cooling.

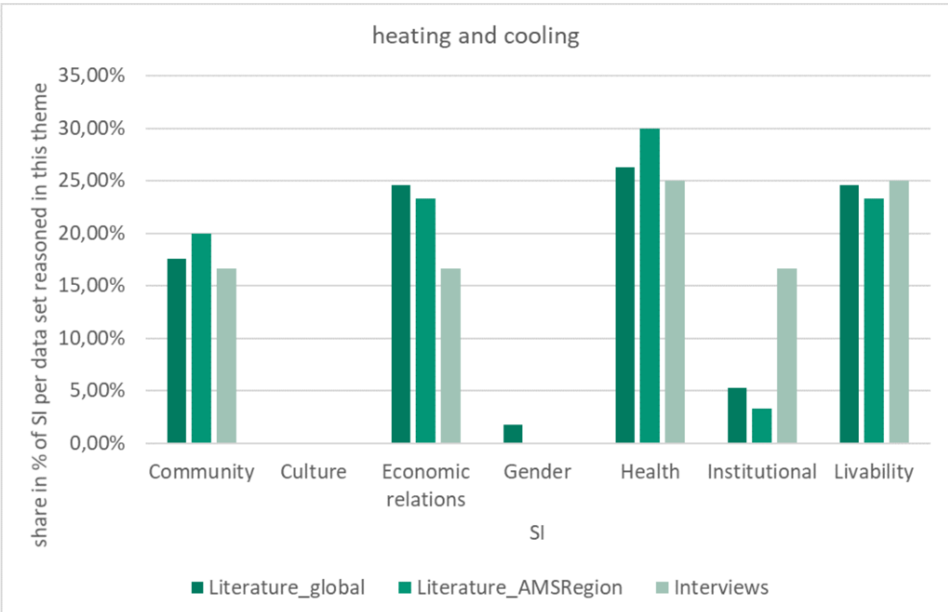


Figure 7.13: Distribution of SI % per each of the three data sets labelled as additionally reasoned in the theme of heating and cooling.

In this theme, social impacts in the SI of **health** were the most prevalent. The **well-being** of residents, as well as the **quality of housing** and the adequacy of **physical infrastructure** were social impacts

frequently mentioned due to this interdependency. The interviewees however, also saw the **participation in decision-making** impacted through the transformation of heating systems. In particular this related to building ownership, incapacity to participate in heating-related decisions and complicated processes in home owner associations.
Both perspectives saw economic relations impacts as third most prevalent impacts next to livability and health. Energy expenses, rather related to heating than cooling, defined and manifesting in impacts on **income, living standards and implications for economic dependency** appeared. The questions of **when to invest and pay for heating and cooling and whether heating and cooling measures can be accommodated in urban fabric** remain open for literature and policymaking to assess and accommodate.
In the sphere of cooling, **health impacts**, mostly related to the UHIE were mentioned (Butters et al., 2020; X. Liu & Sweeney, 2012). In this regard, the behaviour of residents as well as their cooling sensations and the impacts that cooling green space can have were recurring in literature (Mohajeri et al., 2019; Perera et al., 2023; Salvati & Coch, 2021), but also in the interviews.
/ Lastly, both perspectives related these impacts to second order **social differentiation** impacts. The additionally reasoned social impacts largely mirrored the stated.
The theme factors identified in the analysis and the prevalent social impacts of this theme are shown in Figure 7.14.

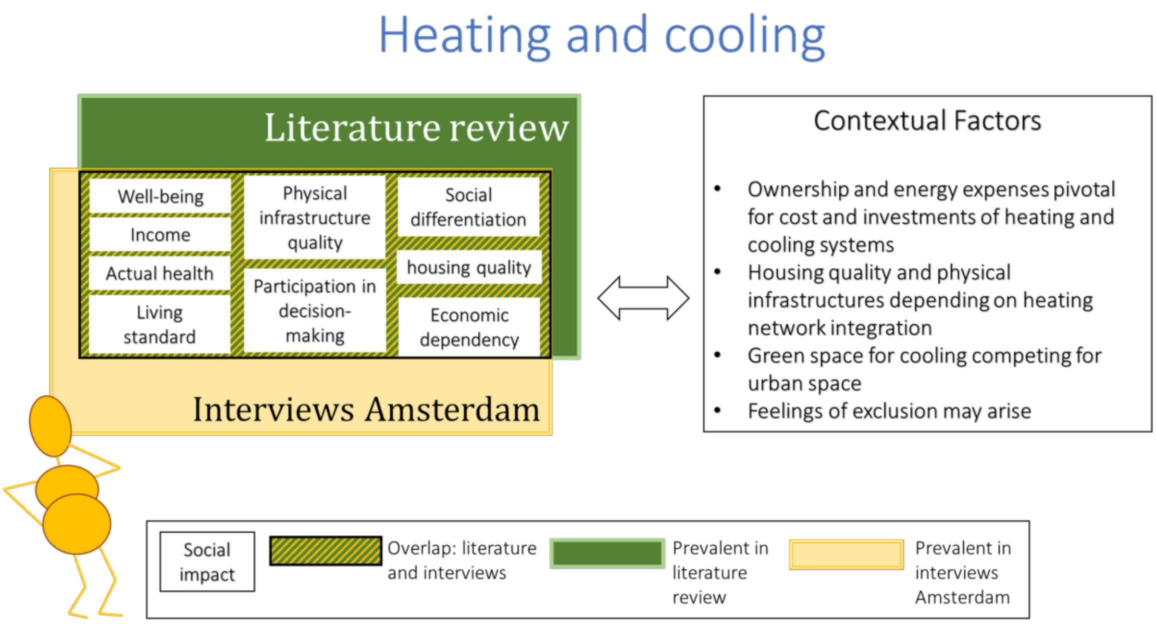


Figure 7.14: Prevalent individual social impacts and contextual factors discerned from the two perspectives in the heating and cooling theme.

Heating and cooling examples

For the full text version of these examples regard Appendix E.4.

Well-being, actual health and housing quality in both perspectives

Perera et al. (2023) point out the impact of human behaviour. In their study occupant behaviour relates strongly to their thermal sensation. The cooling needs are not only due to temperatures, humidity and air velocity, which can be impacted by CC and urban form, but also by occupant activity and clothing level, determining well-being. While this results in the author's focus on commercial buildings to reduce uncertainties, it gives important CA indications for the inclusion of human behaviour into the assessment.
The strong impact that architecture can exert on well-being and heating and cooling behaviours is subject to the study of Salvati and Coch (2021). Assessing Mediterranean climates, they stress the importance of building ventilation, humidity regulation and protection from accumulated solar radiation to prevent heat stress, excessive cold or heat seasons.

Respondent G raised the attention to the feedback impact that the increase in the number of air-conditioning units (AC) has on the temperature development within the city and the demand on the electricity grid. Population groups that depend on AC during heat periods may be particularly vulnerable if AC cannot be sustained in a densified, warmer environment (C.4.4, ID 11, ID 16).
The energy expenses created through cooling pursuits were described by Miner et al. (2017, p. 193). The authors concluded that in the case of the UHIE as an extreme event and hazard for especially vulnerable groups,

> "the most likely strategy pursued by individuals would be to invest in more air-conditioning capacity, which will typically increase household energy consumption, exacerbating the issues [i.e. the self-reinforcing nature of the UHIE]."

Respondent E emphasises the potential of insulation improvements during densification. This improvement of the housing stock would be an opportunity to increase health, well-being and lower the recurrent energy bills of residents (C.4.2, ID 13).
The decision and investment for more sustainable heat sources, connection to the district heating network or installation of hot/cold-storage systems is an additional barrier for residents of lower income and tenants. However, if the housing owner takes this step, the improvement of the housing quality may become very beneficial to the living standard and health of the residents in the long term, after a period of nuisance in the construction and renovation phase (C.4.6, ID 10, ID 11). This relationship and ownership issue can be seen as one of the symptoms and causes of social differentiation and lack of or opportunity of participation in decision-making in the heating transition.
Moreover, heating was claimed as one of the areas of the ET, where building ownership is pivotal. For the ownership communities, less emitting energy sources for heating are frequently linked to investments into building stock and backlog in the renovation. When these obstacles are overcome financially, the voting processes in the communities may be challenging to the uptake of new heating solutions. In these cases, the municipality would like to connect ownership communities to each other and offers training for knowledge exchange (C.4.6, ID 8, ID 9). Respondent J reflected on the chances for community interaction in the neighbourhood if energy sourcing and storage are managed in local systems. The ownership of energy production communities may lead to a feeling of participation in the ET and increase community cohesion. However, the inclusion of residents in social housing and low-income owners may lack behind, which could propagate feelings of exclusion (C.4.7, ID 21).

7.3.5. Electricity and energy sources and grid

Overview

Finally, considering the energy and electricity sources and grid, the divergence between the two data sets is the most evident. The Overview of stated SIs in this theme is given in Figure 7.15. The reasoned SIs are included in Figure 7.16.
While in the literature review, I identified living standard, physical infrastructure and social differentiation most frequently, from the interviews I discerned participation in decision-making, actual health and feelings leading to the formation of interest groups as prevalent.
In the impacts I reasoned, impacts on autonomy and property values were added in the literature data set. In the interviews, I reasoned many diverse additional impacts from the policymakers' perceptions. Amongst these the housing quality, but also social network disruption, violence and stigmatisation.
As the interview questions and search strings were based on the CM and understanding laid out in Chapters 3 and 2, the underlying bias may have contributed to this outcome.
In the **theme of electricity and energy sources and grid**, the following questions arise: **Who owns the new housing units? Who owns electricity generation sources? How will electrification interact with the residents' behaviour patterns?** These questions will define the notions of participation in decision-making, the formation of interest groups and are therefore important to accommodate in policymaking. As the physical infrastructure is changed and living standards and economic dependency and vulnerability may be defined to large extends by who will be able to take decisions, i.e. questions of ownership and participation, a regulation of these processes is necessary. In this way matters of social differentiation and the achievement of actual health benefits and higher housing quality levels after densification has happened may be guided.
The visual representation of the insights in this theme are shown in Figure 7.17.

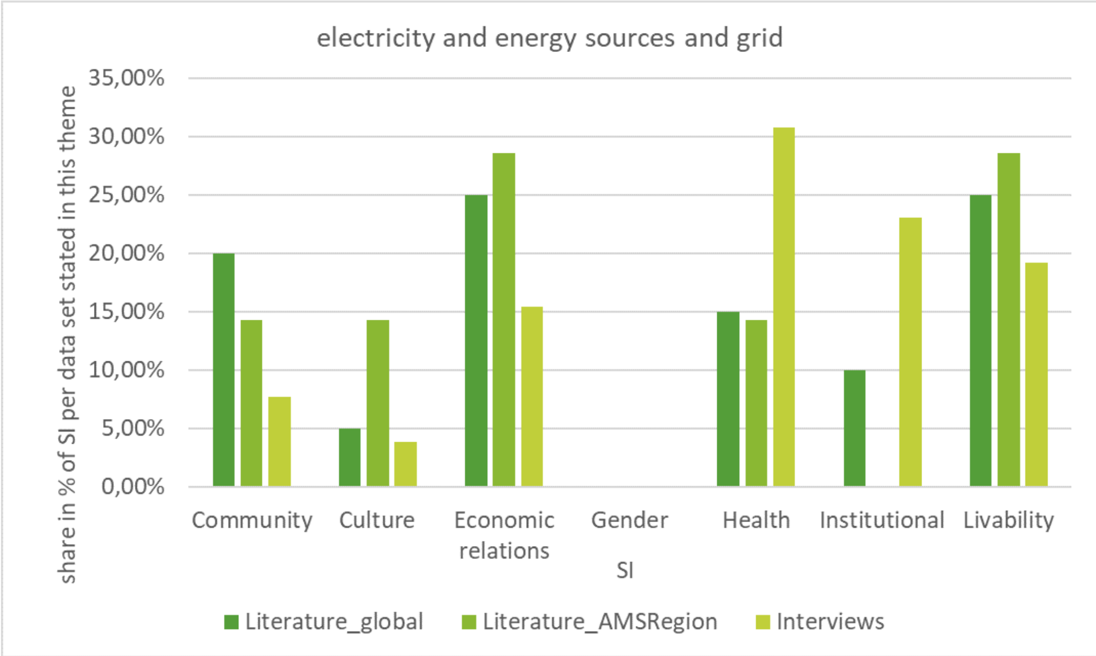


Figure 7.15: Distribution of SI % per each of the three data sets labelled as stated in the theme of energy sources and grid.

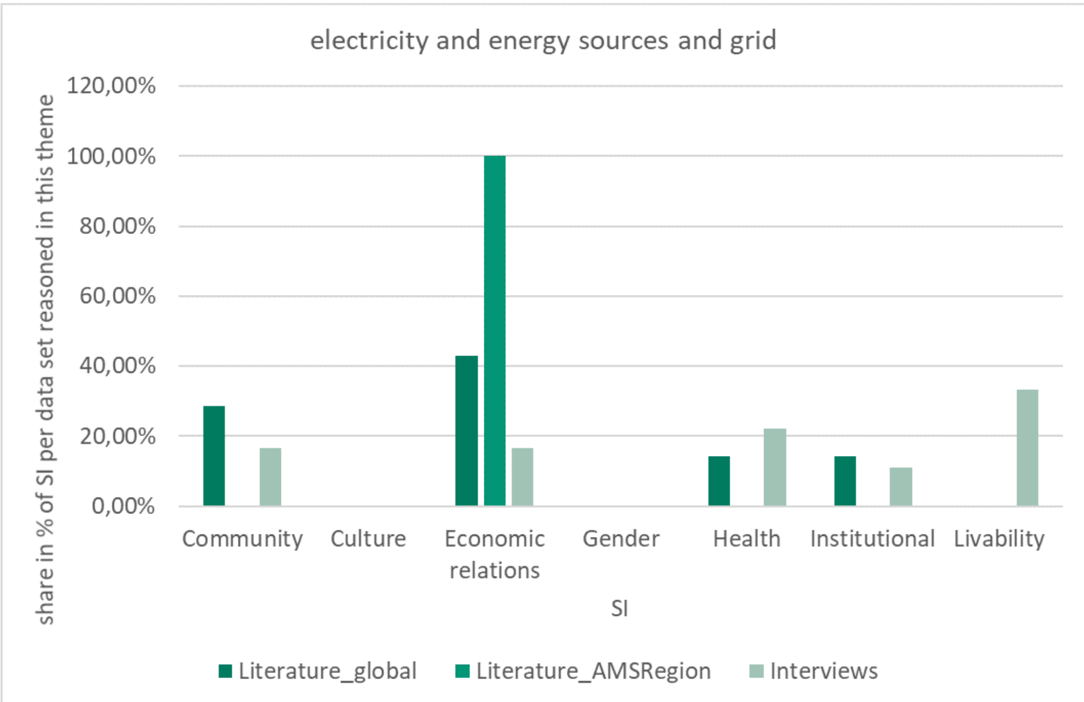


Figure 7.16: Distribution of SI % per each of the three data sets labelled as additionally reasoned in the theme of electric and energy sources and grid.

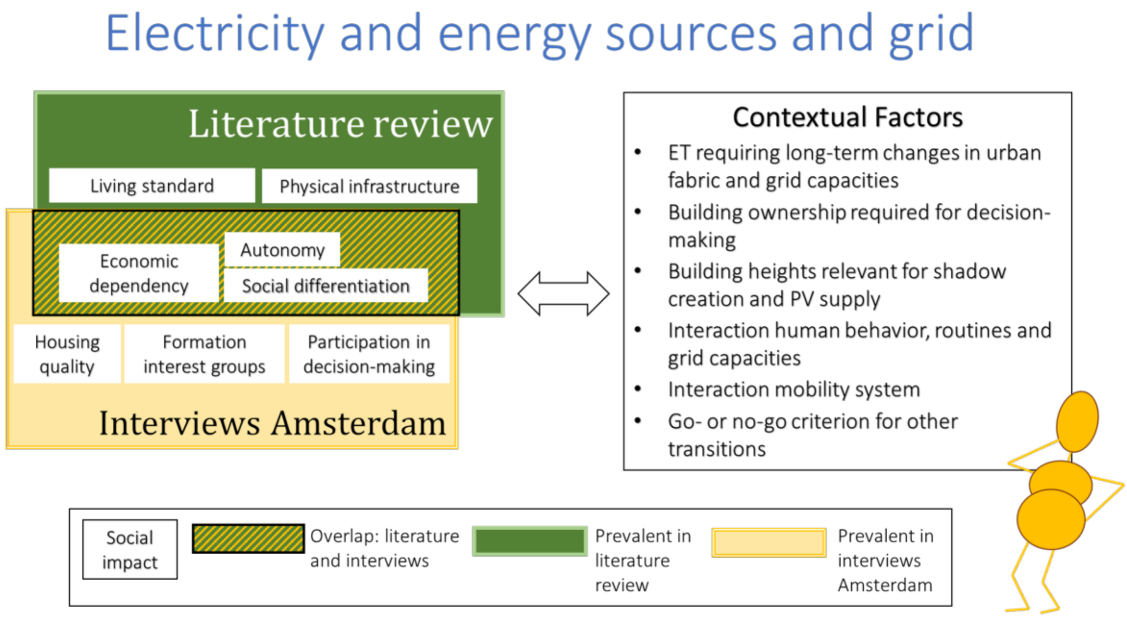


Figure 7.17: Prevalent individual social impacts and theme factors discerned from the two perspectives in the electricity and energy sources and grid theme.

Electric and thermal energy sources and grid examples

Housing quality in the interviews

Participant I reflects on the complexity of demand changes that can occur in certain densification development. If the use function of a building is changed form business or industrial use to residential use, this affects the needed capacities, and, most of all, the energy usage curve (C.4.6, ID 3). Difficulties were expressed by a respondent for the spatial and financial inclusion of storage solutions (C.4.7, ID 21).

Space is competed for, and integrated solutions are needed to accommodate as many claims as possible, the energy and electricity systems are high ranking on the list as they are a go or no go criterion for other spatial claims (C.4.9, ID 18)

If densification leads to an increase in sharing of appliances and facilities, the absolute electricity and thermal or other energy demand might by higher than in less dense areas - but the per capita use can be decreased and more efficient solutions brought to the table (C.4.1, ID 18; C.4.8, ID 2). Connected to this, the grid capacity needs to be brought up to speed. Whereas respondent F during the time of the interview wished for more consideration of the peak grid demands in the densifying areas and the city as a whole by the municipality (C.4.3, ID 18), the participant stressed in a follow-up communication in September that strategy efforts in planning have been made.

Living standards, economic dependency, social differentiation in literature

In their 2012 study, Byrd and Ho (2012) concluded that suburban forms might prove to be energy efficient when electric vehicles (EV) are combined as storage and transport technology with PVs on roof areas as these might generate larger electricity harvests there than in compact city centers. However, ownership distributions of suburban houses and EV might account for social differentiation in the local profit of these electricity and mobility systems.

In Byrne et al. (2016), social differentiation exists in the described characteristics of solar panel owners. House owners with higher living standard features were more likely to own solar PV. In contrast to these, renters and persons with higher energy expenses were more likely not to be owners of solar PV panels. The authors relate this association to the non-ability of tenants to decide on the installation of solar PV. Moreover, as the authors state

"[l]andlords may act to limit financial outlays and to maximise their rental returns, seeing limited value in installing high-end, energy efficient appliances that could be damaged by tenants. Operating costs are not their concern because they are passed onto tenants (who pay for electricity)" (Byrne et al., 2016, p. 13).

How electricity outputs from rooftop solar PV might be high despite compact built environments was suggested by Mohajeri et al. (2019). If building heights are levelled out during a densification process by topping up lower buildings, shadow creation between buildings might be reduced, increasing the solar gains.
Considering the cost of the ET, Perera et al. (2023) concluded in their study, that the uncertainties in CC developments in combination with the integration of renewable energy sources might depend on urban forms, local climates and grids. In this way, physical infrastructures might not only be determined by the advances in technology, but also the local conditions.
In a combined consideration of climate developments and CA, Butters et al. (2020) observe municipal energy grid lock-ins. These might lead to economic vulnerabilities in particular in poorer regions where

"favorable solutions such as district heating or cooling are not implemented", leading to "huge future energy costs and climate emissions" (Butters et al., 2020, p. 200).

Participation in decision-making, social differentiation and formation of interest groups in the interviews
The electricity sources in the densified urban environment are another demand for space. The installment of solar PV on roofs will encounter a lower number in suitable roof space. However, they are better manageable than windmills, which face public opposition in dense residential areas (C.4.4, ID 17; C.4.2, ID 8, ID 9, ID 10). Respondent E in this regard elaborated further, that when space becomes scarce in a densification context, the competition between other functions and, in this case windmills, gets harder. In densely populated areas, as the population count is higher, also a larger group of residents might be affected by potentially or perceived negative impacts. For this reason, the formation of opposition groups might climb (C.4.2, ID 9).
Considering ownership, the placement of solar PV often encounters similar difficulties and investment constellations as heating options. ET pursuits in the urban space creates both, resident opposition and promotion groups. However, it may also be an opportunity of public participation in the shaping of the ET (C.4.2, ID 10).
Participant K gave weight to the increased energy prices and awareness about energy consumption. In this regard, they elaborated on human behaviour and routine changes. The understanding of the energy system might change due to the ET and the transition might require more participation and interaction with the energy system on the one hand. On the other, energy poverty might already impact residents' behaviour and restrict their routines, leading to, or, correlating with, social inequality (C.4.8, ID 5, ID 6).

7.3.6. Contextual theme factors overview

The matched theme relationships in the three-dimensional socio-technical system of urban densification, CA transitions, and social impacts are shown in Figure 7.18. This juxtaposition reflects the variety of theme factors that are common or particular to the method strains. The factors particular to one of the data sets are included in the horizontal literature review box (top, light green) or the interview box (bottom, yellow). Factors in the overlapping space of both boxes are common to both perspectives. Common to all themes and both data sets is the factor of gentrification and urban inequality - a strong example of the complex social impacts and rootedness spatial interventions and CA.

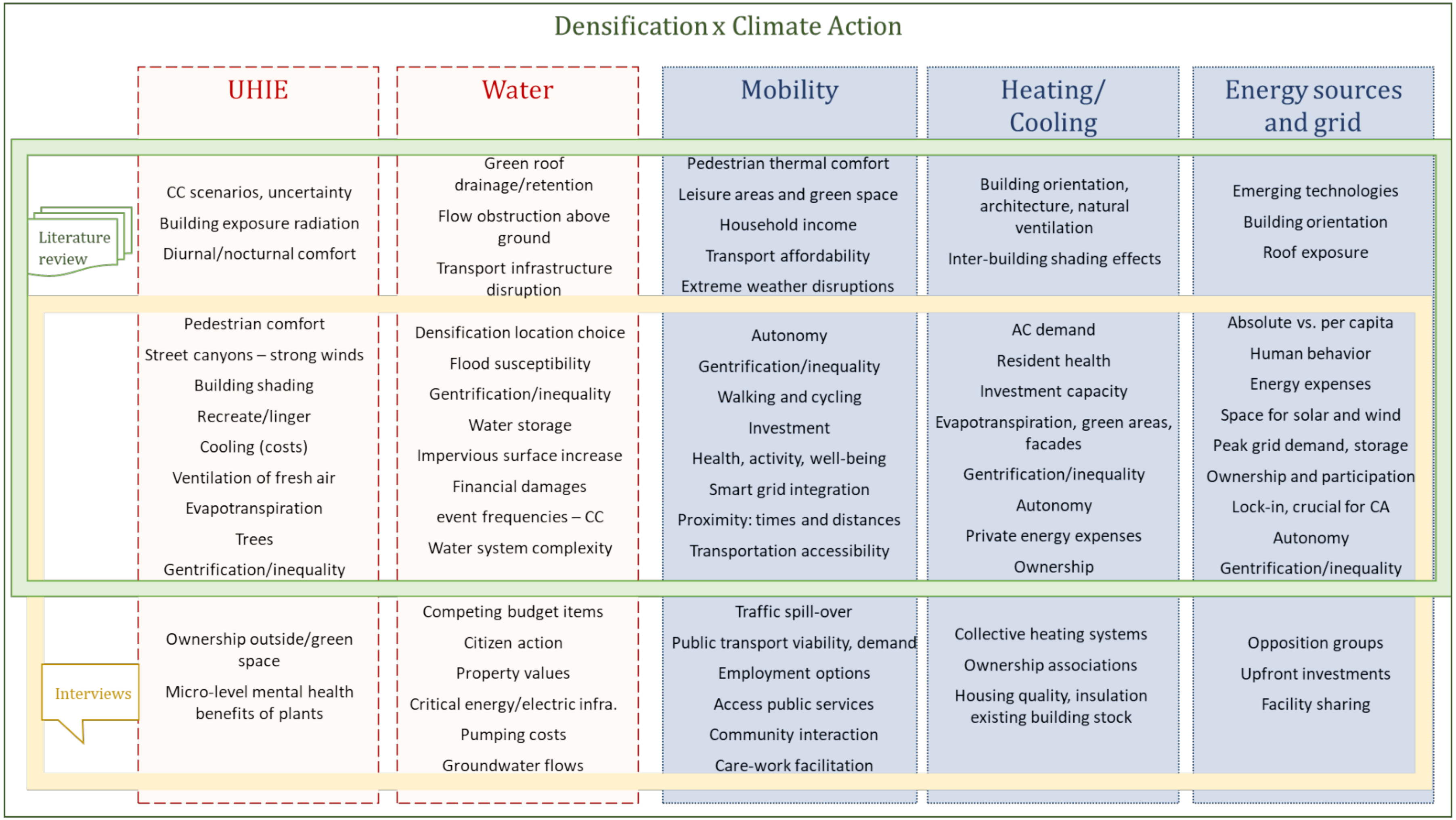


Figure 7.18: Three-dimensional juxtaposition of factors in the themes discerned from the two perspectives. The five CA themes (red, long dash and blue, round dot) are embedded in the simultaneous built environment densification process (green outside frame line). The factors unique to one of the data sets are included in the horizontal literature review box (top, light green) or the interview box (bottom, yellow). Factors in the middle space are common to both strains.

Chapter 8

Discussion

Finally, Section 8.1 ties together the results that I presented in Chapters 5 to 7. I refer to hot-spots for future research in Section 8.2 and urban policymaking in a general sense in Section 8.3. In Section 8.4 I use the results of this study to draw implications for the densification development variants in Amsterdam. To close off, I reflect on the limitations and suitability of the chosen approach in this thesis in Section 8.5.

8.1. Findings in the two perspectives

My study goes in parallel to the results of Westerink et al. (2013) that the change processes arising from densification may lead to **adverse and beneficial impacts alike**. Moreover, I could show that there is a **divergence between scholarship and planner's perceptions.** This enriches the knowledge of divergences already identified by Ahlfeldt and Pietrostefani (2017) between abstract and empirical studies, as well as of Berghauser Pont et al. (2021) between planning motivations in policy-documents and academia.

By reducing the literature review data set to the 45 items in the AMS-region, I could test the trends in the literature review data. The results in the majority of themes show the same trends of prevalent SI, whether the literature review includes all regions, or only the AMS-region items. Deviations were strongest in the **electricity and energy sources and grid theme**. In particular, comparing the policymakers' perceptions with the AMS-region literature, the most prevalent SI do not align. This gives the indication that in this theme, there is a **gap between regional literature and policymaking**. Another distinction could be made in the **heating and cooling interdependency**. Here, the global literature set referred stronger to the SI economic relations and mentions institutional impacts. Within my resources I can only assume one out of two things: that literature in the AMS-region does not perceive economic relation impacts as as much as the global literature, or, that research findings indicate lower impacts in this region.

In the **UHIE and Water themes**, the factors particular to the literature review data set seem to adhere to physical relationships, the factor or transport infrastructure disruption in the water theme. Many of the factors filtered from the interviews are rooted in societal interactions (ownership, budget competitiveness, citizen action, property values, pumping activities and costs). This might be due to the practice background of the interviewees in contrast to the academic characteristics of the review items. The financial quality of the factors in the **water theme** of the interviews mirror the prevalence of the SI of economic relations. Also the other diverging factors in UHIE and health may be linked to the strong occurrence of health and livability impacts in the literature review data and health in the interview data. In the **mobility theme**, the diverging factors in the two perspectives mirror the prevalent SI: the community and economic relations in the literature review and the economic relations and health impacts analysed for the interviews. The factors common to both data sets show deep embedding into the objectives of densification as a spatial planning doctrine: proximity, multifunctionality, independent and low-emission transportation modes. This shows that the perception of the social impacts of policymakers and the impacts stated in literature overlap with the goals of densification in this theme. The most frequent SI of the **heating and cooling theme** in the literature review are not represented in the particular theme factors, but rather in the factors common to both data sets. The particular factors in the literature review, again, are of a more physical nature. The factor prevalent in the interview data set

(collective heating systems, ownership associations, housing quality and insulation) reflect strength of the livability and community SIs.
At last, the theme of the **energy and electricity sources and grid** provides factors that are particular to the two perspectives as well as common. While the three factors discerned from the literature data set focus on livability and new technologies, the factors particular to the interviews adhere to institutional and health, as well as livability and economic relations impacts.

Social justice

In my research, the complexity of social impact observation as per Imperiale and Vanclay (2023) became apparent at many instances. My results show that next to first order and direct social impacts, many indirect impacts may occur. These are explicitly mentioned, but sometimes only implicit to both my data sets. Through reasoning I could shed light on these implicit and often indirect social impacts arising from interdependencies between densification and CA.
The recurring impacts of social differentiation, notions about impact fairness and equity, the formation of interest groups and the participation in decision-making are social impacts that are decisive in the eradication or propagation of urban inequalities Byrne et al. (2016) and Williams et al. (2023). Similar impacts were observed by Berghauser Pont et al. (2021).
An example discussed in both perspectives of this thesis project was the impact of access to sites, capacity of investment and favorable location characteristics for PV electricity generation. These contextual factors easily influence the justice dimensions and experience of equity of affected urban residents. This example reflects the social justice concerns raised by Bennett et al. (2023) and Ghisellini et al. (2023) and constitutes one of the many leverage points striving for local equity in the ET that my thesis unveils.
Home ownership is evidently decisive in this matter. Tenants may often be excluded from greater economic independence, participation in the ET and better housing quality in the form of energy performance. The absence or low quality of modern physical infrastructures does not only lead to lower living standards, but could restrict the progression of the ET if landlords do not see the installation of PV as renewable energy source and the upgrade of the building's energy performance as advantageous.

Vulnerability

Inequality in vulnerabilities of residents is represented in my results on many occasions. The example of availability of mobility modes in the densified environment spotlights such a vulnerability inequality. The experience of disruptions due to urban densification might be much stronger for population groups dependent on individual motorised transport as stated in the interviews. Also the effect of water damages after flood events will be experienced differently in line with the recipient's vulnerability and underlines the importance of vulnerability assessments in CCA as in Filho et al. (2018) and O'Brien et al. (2006).

8.2. Hot-spots for future research

In general, the knowledge base can serve as a data base to establish further research which is necessary to be able to better estimate the effect of contextual settings. Considering the SI occurrence in the two data sets, the SIs of health, community, institutional and gender impacts had frequent implicit mentioning that I could reason from the data. Relationships between densification and CA and social impacts within these SIs should be subject to future research.

8.2.1. Drawing from the literature review statistics

Regions and countries

I could show that within my database, most articles have been published in Europe, with North American regions in second place and followed by Eastern Asia. This also relates to the countries of study, even though authors of course would not need to choose the region they are based in as their study area, particularly so in studies making use of digital remote data collection. Similar prevalence of regions is found in the review work of Ahlfeldt and Pietrostefani (2017).
While this needs to be seen at the background of my search parameters, and in particular the language limitation, it would be important to increase the studies conducted in South America, on the African continent and Central Asia in future work. This would **increase the diversity of viewpoints** and in the end could **help to reveal biases** in research on the topic and in the classification and characterisation of social impacts of urban densification.

Fields, methods and scales of study

Considering the fields of studies, mainly founded on the authors' professional location and the journal the item was published in, a majority of engineering and natural sciences can be distinguished. Humanities and sociology are represented at lower numbers in aspects of geography, urban development, economics and sociology. As can be seen in the study of Ahlfeldt and Pietrostefani (2017) who found the largest number of studies in the field of economics, other authors come to different prevalent scientific fields. Even though this outcome is evidently strongly related to the chosen search strings, it can give indications for future research. My approach, which made strong use of an engineering and natural science understanding of densification and CA in the outset and collection of search items, used a sociological analysis framework. **Future work could further engage in a combination of approaches**. This focus might also be one of the sources for the lower observation of economic impacts in my literature review data set, in contrast to Ahlfeldt and Pietrostefani (2017), but also the work of Cavicchia and Cucca (2020). The latter focusing on strong relations between densification, housing affordability and neighbourhood segregation in their review of the social benefits of urban densification.

Excluding the method of spatial data analysis, because of its various potential facets, quantitative and modelling methods are the main methods applied, with energy, transport and hydrological systems in the focus. Resident surveys, the first strong qualitative method, is represented with 5 items. These studies looked into the quality and perception of green spaces (Byrne et al., 2016; Everett et al., 2018), GHG emissions and energy consumption of households (Muñiz & Rojas, 2019) and neighbourhood perception and satisfaction (Arnberger, 2012; Mouratidis, 2018, 2019). Only two studies applied interview approaches.
For future research in the topic I give the **strong indication to consider residents' perspectives**. Ideally, future studies based on this thesis project and the created knowledge base will include the voices of affected citizen groups to add this essential element which is indispensable to socially sustainable development, fostering social equity. This could be founded on longitudinal studies, considering the social impacts arising from these bio-physical process changes before and after they have occurred. Combining public participation and science communication, Mielby and Henriksen (2020) suggest a citizen science approach to increase the awareness about risks related to natural hazards and to close monitoring and data gaps.

Analyses of the topographic and socio-economic patterns of the case study areas mentioned in the literature review could be conducted. This project could not look at the areas that were already densified or determined for future densification. Spatial auto-correlation analysis of topographic information and socio-economic and demographic information of these neighbourhoods could provide insight into the selection of densification development.

Material Flow Analysis studies and Life-cycle Assessments on urban densification could provide a quantification of material flows and environmental impacts of densification. The mapping of material flows can help to understand the socio-technological system, change workflows and processes to increase the system's (social) sustainability.

Lastly, considering the scales the studies were conducted on, **research on block, district, metropolitan area, region or building scale** were in the minority in contrast to city scale or neighbourhood scale studies. Morelli and Cunha (2021) identified a knowledge gap due to missing **data for small sized cities**. These are data that might be useful to decision-makers and are available at mid- to large-sized cities. Here, future research could be conducted to fill this gap. Nonetheless outside my scope, I consider the canopy-scale, peri-urban area and village scale as addition to my project which helped me to gain additional insights. A particular area for future research was given by Mielby and Henriksen (2020) and Rosenberger et al. (2021) who claim the necessity to conduct further research in **underground systems**, such as hydrological, geological and human-made system interactions as CA and densification may lead to currently unforeseen (social and physical) impacts.

8.2.2. Drawing from SI statistics

Absent and prevalent SI

The **major SIs throughout the project were livability, health and economic relations**. Even though categorised differently and with a different scope, where categories and scopes overlap, these findings largely overlap with the literature review results of Berghauser Pont et al. (2021). Impacts on property values in my study are ambiguous as well, depending on the context. The impact on public finances was less prevalent in my analysis. But, I can only give an indication as I did not characterise identified impacts. My approach was intended to provide **insight into the absence, presence or prevalence or social impacts.** The quality or strength of the impact, or a positive or negative perception at the end of the individual subjects, the urban users or residents, lay beyond my scope. Nonetheless, with some of the social impacts, the reader might already interpret a positive or negative reception and effect on the subject. Here, I want to pose a call for caution as **future research is necessary to actually evaluate** and in particular longitudinally assess these characteristics.

Apart from this, it became clear in the observation on the level of the individual social impacts, that the **SI community** was to a large extent determined by social impacts arising from the interdependencies on **social differentiation**. The other social impacts in this SI as well as the **cultural and gender SI were frequently absent**. However, this should not be seen as a hint that these SIs are not impacted by densification processes in times of CA. As I could show due to the higher numbers of reasoned impacts based on my understanding and shown in Chapter 3, studies in the urban social fabric do depict such impacts. **Future research could dive into the exploration of prevalent SIs and theme factors in the knowledge base and analysis results of my project.**

Divergence between the two perspectives: Institutional impacts

Comparing major social impacts mentioned implicitly or explicitly in literature and the perceptions of policymakers, it became clear that there is an extraordinary divergence between the weight given to institutional impacts. This holds even where the literature set is reduced to items in the AMS-region. For this reason, in particular with regards to impacts on participation in decision-making, **it needs to be further evaluated where this contrasting assessment originates from.** Moreover, it might be an indication of the interviewees' focus on the implementation of urban interventions in contrast to the modelling or simulation of densification and CA interventions engaged in by researchers. The indication of a majority of quantitative and natural science and engineering research methods used in the studies that I gave above might be one of the contributing factors for this gap.

Within the interdependencies

In the mobility theme, autonomy is one of the major impacts in global literature. Research in the **interdependency of mobility** on the autonomy impacts was low in the literature set reduced to the AMS-region. However, the policymakers perceived this widely. Here, it seems that the two perspectives need to communicate further. The often mentioned necessary additional tools and policies that the interviewees brought forward in the mobility theme mark a sphere where research can further support policymaking.

Overall, there were strong overlaps in the stated and reasoned impacts in the **heating and cooling interdependency**. Potentially due to climate, the focus of the policymakers in Amsterdam lay stronger on heating than on cooling. Particularly in the global literature set, cooling was a more frequent subject and often not only related to green space, but also to building construction and architecture. For the case of Amsterdam and regions with a similar climate, further evaluation of the effects of densification and simultaneous ET and CCA on heating could be investigated.

8.2.3. Drawing from the contextual factors

Rinkinen et al. (2021) summarise literature pointing out that the environmental and technological sustainability of urban densification depends on the residents' behaviour, determining the sustainability rating of urban densification processes. The power of human behaviour as brought forward by authors is on the agenda of urban policymakers.

The behaviour of residents and their notions about the equity of interventions can determine the success of densification in times of CA. Physical and mental health benefits often stated by the interviewees depend on the **actual behaviour of residents**, as mentioned by K. However, the spill-over effects of

increased walking and cycling into adjacent neighbourhoods, where infrastructures are less available could nudge residents of these areas nonetheless to walk and cycle more.
The **social behaviour of urban residents** remains an important variable for the outcome of densification interventions which cannot be addressed in the project at hand. In the best case, this needs to be approached with longitudinal approaches that give urban residents a voice.

Another item for **future research needs to be the influence of home ownership** on the perception of densification. This aspect is also expected to influence the autonomy of urban residents engaging in urban transition measures, such as the installation of PV, housing insulation or CCM (Byrne et al., 2016).

The literature directly addressed the **need for stronger investment** into modelling tools for the observation of thermal conditions (e.g. A. Oliveira et al. (2021), Palusci et al. (2022), and Pramanik et al. (2022) and outside the knowledge base Koutra et al. (2018)), the establishment of new indicators to monitor urban development impacts (e.g. Bobylev (2016)) or the provision of household information (e.g. Kaza (2020)) to improve research on urban densification. The inclusion of emerging technologies into urban planning and energy system models was emphasised by Mohajeri et al. (2019). These could feed into research on the social impacts of these interventions in times of CA.

8.3. Indications for policymaking

8.3.1. Effect of human behaviour

The interviews also identified human behaviour and changing societal paradigms and habits as a crucial factor in the social impact outcome, just as Rinkinen et al. (2021). To accommodate for "unforeseen" developments is indispensable to prevent the lock-in of practices through technologies, engineering and architecture. **If spatial planning and architecture are designed for current technologies and prevalent practices, i.e. status quo majority ideas, it might not be fit for minority practices or changed circumstances in the future** (Ahmadian et al., 2019; Rinkinen et al., 2021). Gone wrong, this could generate discriminating disadvantages, undermine the populations' resilience and perpetuate inequalities. As Rinkinen et al. (2021, p. 84) state: "It is only by detailing the material arrangements around which daily lives revolve that the spatial organisation of social practice can be identified as that is reproduced within homes, neighbourhoods, and more extensive infrastructures and systems of provision."

8.3.2. Communication between stakeholders

On the side of **governance, science communication and intra- and inter-agency communication** need to be increased to diminish knowledge silos and to close knowledge gaps on this side as the lack of knowledge and guidance and planning regulations for the integration of CCA in densification processes at municipal departments can be a barrier to sustainable densification (Erlwein et al., 2023; Gadish et al., 2023) and may even deteriorate hazards (Moravej et al., 2022). Awareness-raising and citizen involvement was demanded by e.g. Erlwein et al. (2023) and Miner et al. (2017) but also by the interviewees.
But, in general, communication amongst all stakeholders will strongly affect the social impacts densification and CA can exert. This includes tenants, home owners, municipal or non-governmental organisations or co-operations and corporations. In relation to the ET, the exemplary question of how much does the city under question cooperate with amenity and resource providers within its boundaries might lead to powerful consequences. This was identified in the interviews and aligns with Rinkinen et al. (2021, p. 82), who stated that service providers such as "[...] water companies, food manufacturers, appliance designers and energy providers are involved in making and reproducing the material arrangements on which everyday practices depend" and ought to be part of the discussion.

8.3.3. Locations and necessity of adaptive planning

The **consideration of densification locations** and accompanying policies for the consideration of equity impacts was raised by Butters et al. (2020) and Venter et al. (2023). Similarly, Ricart et al. (2022, p. 19) stressed that "building resilience is about enhancing coping, adaptive, and transformative capacities altogether and not only from a technological perspective but from a social dimension to identify the most relevant and effective strategies for improving urban climate risk management." Also Mughal

et al. (2020) recommended the potential need for limiting densification in already dense areas. In this way, the two studies can be seen as bridge between the recommendations of research for a socially sustainable densification development in parallel with CA, and planning and policymaking practice. Thereby, overcoming the knowledge silos between the two is of highest importance.
Considering public health in extreme events requires the planning of flexible and adaptive urban space. Here, the **quality of the built environment, multifunctionality and transport access** need to be considered with attention. This was mentioned several times in regard to a health crisis such as the Sars CoV-2 pandemic, in the literature data set as well as the interviews: If amenities are closer, a dense city can lead to better physical health through walkable access to health services and amenities (groceries etc), increasing physical health directly (through walking and leaving the restraints of the housing unit) and indirectly (through avoiding higher exposure to virus transmitters as no public transport is used). Like CCA, the inclusion of potential future pandemics into the spatial design thinking process is a component necessary for sustainability.

8.3.4. Learning from the interdependencies

The UHIE, heat, drought

From the strong overlap in the theme of the UHIE between both perspectives, one main common implication can be drawn for policymaking in general: to avoid substantiation of urban inequalities and impacts on social differentiation through densification processes in times of CA, the question of who can use green space is ever more important. This considers that authors and interviewees have opted for the **inclusion of green patches, green facades and green roofs** in densification to avoid impact inequity and social differentiation of urban residents in densifying or surrounding neighbourhoods. My findings overlap with Berghauser Pont et al. (2021) who depicted adverse micro-climate impacts of densification in their literature review.

WATER, flood and rain

The interviewees as well as the literature highlight that monetary costs will occur indirectly or directly due to the water inderdependency. In particular CCA needs to match increased housing unit numbers. The creation of impermeable surface and water flow obstructions below and above ground ought to be prevented. This holds for policymaking and scientific advisors of planning interventions. **Communication between research and practice on the most recent tools** to estimate the impact of construction plans ought to be increased.
On a societal level, the communication between planners and policymaking and residents on the **potentials of damages and the need for resilience and adaptive measures** needs to be strong. This would support the trust in public organisations as well as the viability of planning. At the same time, the impact that this interdependency may have on economic resilience, property values and the resident's living standard need to be brought to the table as the question of who is paying when for which costs to the built environment is already a question of the present.

Mobility

Vulnerable population or vocational groups need to be provided with options of motorised mobility if needed. Financial **investments** into public transport and walking and cycling infrastructure need to keep up with rising population counts and be accompanied by CCA adaptive measures of these infrastructures, such as UHIE preventive shading through green infrastructures and permeable surfaces for rainfall drainage.

Heating and cooling

Study authors suggested **building material** lifetime observation (Resch et al., 2016), material selection for shading, reflection or radiation modification (Gadish et al., 2023), green space inclusion (e.g. Loibl et al. (2021) and Pierer and Creutzig (2019)) or the **orientation and placement of buildings** (Grunwald & Weber, 2021; Kii, 2020; Mohajeri et al., 2019) as general recommendations for urban planning. Particularly if the risk that a combination of materials might lead to temperature increase instead of cooling if combined at random (Kleerekoper et al., 2015) is observed in the interdependency of heating and cooling.
To prevent notions about unfair treatment and gentrification the temporal and actor **distribution of costs for heating and cooling** stays pivotal.

8.4. Indications for Amsterdam

8.4.1. Spotlights prevalent and absent SI

Prevalent: Social impacts in the mobility theme

In Amsterdam, mobility was the theme in which the interviewees explicitly stated the most social impacts. The strong prevalence of mobility is also reflected in the conceptualisation of the densification strategies. This might give an indication of the importance and understanding of densification as an urban form providing **proximity, walkability and accessibility. Closeness of employment options, amenities, social networks,** was recurrent in the interviews. The reduction of mobility not only creates direct social impacts, but also indirect impacts on CCA and the ET. This might be reflected in the reasoned social impacts that were stronger in the cases of the electricity sources and grid and the UHIE.

Little observation: Social impacts in the WATER, flood and rain theme

Strong relations in the published documents of the variant descriptions hint at all themes, reflecting the Amsterdam City Doughnut and the CA policies, with one exception: Water. This may be due to the self-understanding of Amsterdam as "waterstad" (Gemeente Amsterdam, 2023k, p. 8), a city which has been living with and shaping the natural water system in place. However, it seems surprising, that the variants in the development strategy do not in specifically mention social impacts arising from a densification and CA interdependency with relation to water. The Gemeente Amsterdam (2023k) only mentions water in relation to urban green, its functions for evapotranspiration, water storage and drainage. This is particularly surprising as I could show that the interviewees did mention social impacts arising from this theme, even though with lower frequency than the themes of mobility, heating and cooling and the electricity sources and grid. The SIs of livability, economic relations and health were strongest in their perceptions, with the most prevalent social impacts of actual health and well-being, leisure and recreation as well as income, living standards and property values. In this regard the official publication of the proposed strategies seems to be limited. Moreover, the **share of this theme is higher in the implicitly mentioned impacts than in of the explicitly stated impacts**, allowing the indication that there is also more experiential knowledge on the side of policymaking than is actively mentioned by the policymakers. Even though social impacts are perceived by the interviewees, the social pressures are not incorporated in this interdependency.

8.4.2. Indications for the densification strategy

New neighbourhoods

The strategy of new neighbourhoods relates strongly to multifunctionality, and transformation of industrial areas. Here, potential social impacts could particularly occur in the themes of the UHIE. This correlates with participant G who issued a warning to act with precaution to not add to the UHIE by transformation of former industrial areas into residential or mixed-use areas, as these might bear risks for "overheating".

The second theme which might give rise to adverse outcomes of social impacts in this variant is mobility as industrial areas and former harbour areas need to be well embedded into transport infrastructures. Considering interviewee J's experience of areas that are not easily accessible for groups with lower mobility due to handicaps or areas whose residential numbers are increased but without the necessary investments into public transport infrastructure following suit, this is important to mention. I could show that social differentiation, the access to public services and autonomy were also social impacts stated in literature with regards to mobility. Reflecting participant J, Kabisch et al. (2021) also state the importance of green and cool spaces to linger, in particular for pedestrians and cyclists. Here, the interviewees from Amsterdam perceive autonomy and social differentiation impacts stronger than literature of the AMS-region, comparable to the literature items of the non-AMS regions.

I would give the indication to observe cultural and institutional impacts of the UHIE. In literature, the cultural SI impacts are changes in cultural values of the population (Delgado-Capel & Cariñanos, 2020; Martilli, 2014). The institutional impact observed by Ricart et al. (2022) related to urban interventions was participation in the decision-making. This related to education on the adaptive capacity of urban interventions and experimental NBS. Even though outside the AMS-regional literature, Pramanik et al. (2022) highlighted the impact of the UHIE on the notions of fairness of residents in neighbourhoods highly exposed to the UHIE due to a lack of shading and other cooling measures.

Neighbourhood centers/Business, innovation and knowledge centers

This variant is shaped by neighbourhoods with already existing employment options and access to public services, related to the SI economic relations. The feature of an increase of small housing units to accommodate students, scientists and healthcare staff (i.e. highly educated residents) let me draw implications in the themes of the UHIE, heat drought, mobility and the electricity sources and grid. More precisely in the areas of thermal comfort indoors and outdoors, low-cost mobility in the form of cycling, walking and public transport and little space for motorised vehicles. However, also the energy demand would need to be covered. Looking at the literature, outdoor thermal comfort might be increased if shading is increased through high buildings, while maintaining air flows into the built-up blocks (Deng et al., 2023; Erlwein & Pauleit, 2021). This could be improved through the observation of major wind directions (Back et al., 2023). Indoor thermal comfort in the tight urban fabric could be increased through green facades and green roofs (Belcher et al., 2019).
In this regard, Brom et al. (2023) and Lemonsu et al. (2015) overlap with participants G and F, who highlight, that with the population increase, also vulnerability to increases. For this reason, safety and adaptive measures have to be "levelled up". F highlighted the final issue that investments into social services, CCA, the ET and densification alike come from the same budget, the budget of the city of Amsterdam. Densification, CA transitions and the social dimension therefore not only compete for space in the urban fabric, but also public budgets. This was also subject to Tan et al. (2018).
Even though the interviewees referred to this aspect with relation to floods, I want to make this case also for thermal stress. Also with regard to the energy infrastructure, and PV in particular the interviewees and literature agree that ownership and the capacity of tenants to own or invest into solar PV might limit their economic and institutional participation in the ET and with the potential to lead to social differentiation (E, I and J, and (Byrd et al., 2013; Byrne et al., 2016).
This strongly underlines the importance of ownership in the urban space identified in the interviews. The implications of this variant might be highly related to the legal positions of the residents as homeowners in or without an owners' association or as tenants. In relation to the actual electricity generation Mohajeri et al. (2019) remark that building heights could be levelled out to provide a maximum of PV gains.

Station quarters and transport lanes

This variant has strong relations to the themes of heating and cooling, the electricity and energy sources and grid and mobility. Additionally, green space provision is essential to this variant.
As this variant focuses on the establishment of employment options and services rather than housing units, there might be more social benefits than drawbacks. For instance the spill-over effects into adjacent neighbourhoods mentioned by D: accessibility of public services, employment options and indirectly increase autonomy and decrease social differentiation. Such neighbourhoods could be included into the budgeting process as proposed by J.
Nonetheless, the competition for space, urban inequalities and human behaviour might be facets necessary to keep in mind. As in the perception of interviewee G, the shared and non-motorised mobility concepts in this variant might be enablers for the ET - but in a densified surroundings be highly dependent on the space given to these mobility modes and the behaviour of the residents themselves. Another factor is the space allocated to green areas. Pierer and Creutzig (2019) showed the alleviating UHIE and CCA facilitating effect of green space and transport lane combinations, thus maintaining the viability of transport systems, determining residents' autonomy, living standards and health. Lastly, while public transport infrastructure is of low route flexibility in the case of extreme weather events, increasing cycling and walking infrastructures may lift residents' adaptive capacity.

Development of existing residential neighbourhoods

This variant highlights the viability increase of public services due to population increases, also mentioned by J, E, and H. However, as F mentioned, the competition for space is sided with the competition for budgets in the simultaneous pursuit of urban densification and CA interventions. As raised by the interviewee, this also amounts to adaptive measures which have to be installed or improved due to higher population counts. This has been described by Smith et al. (2020) for the case of the US. The authors concluded that in contrast to sprawled cities, dense areas could keep damages costs low. Densification might thus open up budgets that could then be invested into CCA measures.
If the housing stock, physical and social infrastructures are reconstructed and improved, social differentiation or the inability to afford better actual qualities due to income and living standard of the

current residents need to be prevented. This could be accommodated by policies such as a right of return or subsidised parking for former residents or employees in this neighbourhood.
To prevent high-end rents, which would go against the municipal goal of Amsterdam to provide 40 % of housing units in the medium income sector, Muñiz and Dominguez (2020) (non-AMS-region literature data set) suggested stronger housing market regulation. This suggestion was also brought forward by Cavicchia (2023) for the case of Oslo to prevent exclusionary housing market developments.
The observation of health impacts due to the addition of floors needs to be part of this variant, in particular in relation to the UHIE and heating and cooling in times of CA. Green facades, green roofs and small patch green areas could balance out increased cooling demands (Belcher et al., 2019; Loibl et al., 2021; Martilli, 2014; Mohajeri et al., 2019; Perera et al., 2023), "grey landscapes" and lower effects on pollution levels or thermal stress.
Emerging heating and electricity technologies for single households could be incorporated into this variant (Martínez Reverte et al., 2022), while human behaviour and sensation, household compilation and household income will play an important role in the necessary grid capacities not only for heating, but also for cooling technologies (Miner et al., 2017; Perera et al., 2023) in times of increased UHIE and CA and due to the increased population in the existing neighbourhood, which is not - as G stated - a clean sheet to build on.

8.5. Reflections on the chosen approach

Overall, this project underlies the restrictions and benefits of the research approach I chose, as well as limitations due to my resources and positionality.

8.5.1. Conceptualisation of CA, densification and social impacts

First and foremost, I chose a broad definition of urban densification. This relates to the fact that if I had intended to compare only studies with an identical definition, I would not have been able to conduct this literature review. The use of the terms "densification" and "density" has not been standardised and differs between authors, study fields, regions, schools (Ahlfeldt & Pietrostefani, 2017). Also in the perceptions of the policymakers I did not ask for a definition. The aim of my research was to provide a comprehensive and broad overview of the social impacts arising from densification and CA. Here, I did not want to restrict myself yet to only one form or variation of densification processes or one strict definition of density. The results of this project therefore stem from studies with a multitude of distinct densification understandings. The results need to be read at this background.
The approach of Larimian and Sadeghi (2021) to social sustainability dimensions is reflected in the use of the framework of Vanclay (2002), in parts of the Codebook and can also be seen in the literature review knowledge base. But, I did not distinguish between scales within the social impacts compiled in the knowledge base.
The reasoning of the labelled sections was based on literature items collected for this purpose. However, the literature often is ambiguous and still undergoing discussion. The goal was to find conclusive arguments while also taking into account that the reasoning and discussion of social impacts is complex and will be ongoing. This academic review process, hypothesising and falsification naturally also applies to the items that comprise the review results and knowledge base.
The parallel conduction of the literature review and conceptualisation had a strong impact on the interview questions and definitions given in the interview.

8.5.2. Data collection

Literature review

The limitations of this project lead to several items which I could not assess in the literature review.
Firstly, I did not collect or evaluate the definition of densification or densification measures in the articles reviewed. For instance, I did not assess whether the review item focused on CA and only merely touched densification, whether they focused on population density or area density as density definition, or whether they particularly looked at various forms of densification processes or whether this was kept as a general process.

Secondly, the review was limited to the two databases chosen, the search queries and the conceptualisation of the CM. The high counts of certain ET or CCA elements also relates to the search queries and data set created, the results mirror the search queries and are biased in this regard. Moreover, to handle the large number of results especially in relation to the ET, a machine learning algorithm was used. Even though the review reports can be retrieved, this decision comes with the restraints of applying such a tool.

Interviews

The results must be seen at the background of the case study, which is a municipality that is at the forefront of aiming at and budgeting for sustainability in its spatial planning.
The interview sample is subject to a strong sampling bias as it included only a small number of interviewees working in a few departments at the municipality of Amsterdam. Within the time at hand, the semi-structured interviews enabled me nonetheless to explore the topic with a certain depth. Due to time constraints, I could not ask all questions to each interviewee. The online setting of the interviews was sufficient for this research project.
The interview participant sample could be extended to members of other spatial planning departments, e.g. transport, health, education facility planning, as densification ought to be seen and planned across departments to prevent silo-thinking.

8.5.3. Data analysis

The data analysis strongly built on the CM: Via the CM, the themes were not only already part of the development of the interview questions and the search strings, but also, the Codebook on the side of the analysis of the collected data.
A major limitation of the Codebook is that even though the SI labels were based on Vanclay (2002) and technically distinct, some of the labels were related, mainly through first or second order relationships. Moreover, the number of labels/codes was high. Therefore, I encountered a challenging labelling process: while it helped to discern future research areas if all individual social impacts are used, it was challenging to be stringent in the labelling process.
With regards to the labels, I want to mention that the label "uncertainty" could have been assigned to studies highlighting the uncertainty of climate or development scenarios. Even though uncertain CC trajectories might usher residents to having feelings of uncertainty about the future, these did not find way into many of the review items.
Next to the energy expenses impact, it would have been stringent to add an adaptation expenses impact. However, this was left out due to time constraints. Similarly, next to the CCA policy impact, an ET policy impact label could have been added.
The high scoring category of livability and the high scoring codes within the SIs livability and health are not surprising if the location of densification within the sphere of the built environment and the prevalence also of "health" within the search strings are acknowledged.
In general, the frequency of labels in the coding process was limited by my capacity and positionality. For instance, if the frequency of a label was increasing, I cannot preclude that this did not leave to an exponential use of a label due to psychological prevalence effects, where a high frequency lead to a conditioning and increased attention for the impact in question. This can have distorted the label occurrence count.

Conclusion

In the first part of the conclusion I will summarise my main findings answering the RQ and the SRQs. In the second part I reflect on my thesis as the final part of my studies in the IE programme at TU Delft and Leiden University.

9.1. Summarising the findings

At the background of the planetary boundaries and social foundations that comprise the safe and just operating space defined by Rockström et al. (2009) and revisited in Rockström et al. (2023), I set out to explore the social impacts of urban densification, CCA and the ET. I did this driven by the environmental and social justice challenges that we are facing, trying to mitigate and to adapt to in this third decade of the 21st century, to answer the RQ:

Which social impacts arise from simultaneous urban densification and climate action in the form of climate change adaptation and the energy transition?

My intention was to contribute to a better understanding of the research gap and to provide an overview of potential socio-technical system interdependencies between the envisaged urban transitions. In my SRQs, I wanted to shed light on how the urban interventions usher in change processes leading to social impacts to support future research and policymaking.

My results are able to answer the RQ and I summarise my findings for SRQ 1 to SRQ 3 and then for SRQ 4.

SRQ 1: Which social impacts arising from the interdependencies of simultaneous urban densification and climate action-related transitions are explicitly and implicitly mentioned in literature?
SRQ 2: Which social impacts arising from the interdependencies of simultaneous urban densification and climate action-related transitions are perceived by policymakers?
SRQ 3: How does the perception of urban policymakers differ from or overlap with social impacts mentioned in literature?

The analysis of my review data provides a broad knowledge base to answer SRQ 1. I looked at the **explicit and implicit mentioning of social impacts** in academic literature, **arising from the interdependencies**. These I identified as 1) the UHIE, heat and drought, 2) WATER: flood and rain, 3) mobility, 4) heating and cooling, and 5) energy and electricity grid and sources. In the interviews I could collect **perceptions of urban policymakers in the Dutch capital of Amsterdam** to answer SRQ 2. The city is currently pursuing all three transitions in their urban policies and planning strategies. Striving to answer SRQ 3, I could compare the results generated in my literature review with this case study **on the level of broad categories of social impacts** - the SI - as well as **on the individual social impact level**. This was based on the social impact understanding of Slootweg et al. (2001) and Vanclay (2002). The observation of the individual social impacts helped to give an image of the origins of the prevalence or absence of the SIs.

Not surprisingly, **livability impacts,** physical and built environment properties **are frequent** in the data. At the hand of the data collected, there is also a **strong observation of health and economic social impacts** in scholarship and practice. However, **health and economic impacts** are more prevalent than livability impacts in the perception of policymakers. In their perception, densification and CA

interventions often create economic, institutional or community impacts. These stand next to the commonly stated impacts on health.
Institutional impacts and community relations are less frequently documented, while the observation of **cultural or gender impacts is almost absent** from the current debate.

The **policymakers also perceive expected benefits or challenges** of densification in times of the ET and CCA. Generally understood as beneficial are the examples of multifunctionality, proximity or transport accessibility. **Property ownership** and connected capacities and rights, **urban inequality and space competition** are challenges frequently mentioned by the interviewees. While literature considers urban inequalities and to a lesser extend ownership issues, space competition due to the physical constraints of urban space is truly an issue inherent to the experiences of the interview participants. Impacts on urban inequality, or urban inequality as a driver of impacts arising from densification and CA, are overarching in all themes.
The results also revealed that **human behaviour, energy use and expenses, climatic and topographic conditions** are affecting the social impacts and infrastructures in the themes alike.

SRQ 4: Which are the main contextual factors mentioned with regards to these social impacts and what are the implications for research and policymaking?

Future research should be guided by the **observation of residents' perceptions**. I recommend the **combination of natural science and engineering approaches with social sciences** to broaden the scope from bio-physical processes to social change processes.
Nonetheless, this project enabled the **identification of accompanying policies and tools** recommended or requested from scholarship and policymaking. As some relate to data and modelling restrictions, other requests are of legal or economic nature and are challenging to policymaking. The clarification of property rights, provision of public transport, active land use management, or the provision of accessible, affordable and available infrastructures and social services, the budgeting of development not only in prime focus neighbourhoods, but also the surroundings, may challenge communities and governance alike.

To conclude, **my results align with the pool of positive and negative assessment** of urban densification that were brought forward and discussed already decades ago. The **knowledge base** compiles literature contributing to the argument, that **densification planning requires a systems thinking approach and good communication** between stakeholders, researchers and policymakers. Additionally, the social impacts arising from simultaneous densification and CA are highly context driven and require further research and accompanying policies in governance and policymaking. **Densification** can certainly not be seen as a silver bullet for urban development in times of climate action and **needs to be undertaken with the context at hand driving the discussion** and informing decision-making to prevent increased urban inequalities and to foster social unsustainability.

The results of this project can provide a foundation for future research and for the development of strategies enabling densification in times of CA which prevent societal, technological, infrastructural, environmental or climatic lock-ins and which deliver socially sustainable urban development for current residents and future (resident) generations.

9.2. Reflection

After this project, constituting the end of my time in the IE programme, I am proud of, grateful for and happy about what I have learned. Systems thinking was the way to go, enabling the combination of engineering, natural sciences and sociology to understand the social consequences of interventions in the urban built environment.
However, as with many (urban) research projects, the sparring, brainstorming and skills team projects have to offer, could help to bring the understanding and mitigation - or in the best case prevention - of these challenges much further.
I hope to be able to continue working in this field and to bring these issues to the table. It was a great experience that seeing things in perspective can lead to a solid termination of a thesis - and two wonderfully fruitful years of studying IE.

References

Adams, W. C. (2015). Conducting semi-structured interviews. In *Handbook of practical program evaluation* (pp. 492–505). John Wiley & Sons, Ltd. Retrieved August 6, 2023, from https://onlinelibrary.wiley.com/doi/abs/10.1002/9781119171386.ch19

Adger, W. N., Dessai, S., Goulden, M., Hulme, M., Lorenzoni, I., Nelson, D. R., Naess, L. O., Wolf, J., & Wreford, A. (2009). Are there social limits to adaptation to climate change? *Climatic Change*, *93*(3), 335–354. https://doi.org/10.1007/s10584-008-9520-z

Ahlfeldt, G. M., & Pietrostefani, E. (2017). This work is part of the research programme of the urban research programme of the centre for economic performance funded by a grant from the economic and social research council (ESRC). the views expressed are those of the authors and do not represent the views of the ESRC.

Ahmadian, E., Byrd, H., Sodagar, B., Matthewman, S., Kenney, C., & Mills, G. (2019). Energy and the form of cities: The counterintuitive impact of disruptive technologies [Publisher: Taylor & Francis _eprint: https://doi.org/10.1080/00038628.2018.1535422]. *Architectural Science Review*, *62*(2), 145–151. https://doi.org/10.1080/00038628.2018.1535422

Akinci, Z. S., Delclòs-Alió, X., Vich, G., & Miralles-Guasch, C. (2021). Neighborhood urban design and outdoor later life: An objective assessment of out-of-home time and physical activity among older adults in barcelona [Publisher: Human Kinetics Section: Journal of Aging and Physical Activity]. *Journal of Aging and Physical Activity*, *29*(5), 781–792. https://doi.org/10.1123/japa.2020-0254

Al-mosa, Y., Parkinson, J., & Rundle-Thiele, S. (2017). A socioecological examination of observing littering behavior [Publisher: Routledge _eprint: https://doi.org/10.1080/10495142.2017.1326354]. *Journal of Nonprofit & Public Sector Marketing*, *29*(3), 235–253. https://doi.org/10.1080/10495142.2017.1326354

Ambrey, C., Byrne, J., Matthews, T., Davison, A., Portanger, C., & Lo, A. (2017). Cultivating climate justice: Green infrastructure and suburban disadvantage in australia. *Applied Geography*, *89*, 52–60. https://doi.org/10.1016/j.apgeog.2017.10.002

Antoniadis, D., Katsoulas, N., & Papanastasiou, D. (2020). Thermal environment of urban schoolyards: Current and future design with respect to children's thermal comfort [Number: 11 Publisher: Multidisciplinary Digital Publishing Institute]. *Atmosphere*, *11*(11), 1144. https://doi.org/10.3390/atmos11111144

Arnberger, A. (2012). Urban Densification and Recreational Quality of Public Urban Green Spaces—A Viennese Case Study [Number: 4 Publisher: Molecular Diversity Preservation International]. *Sustainability*, *4*(4), 703–720. https://doi.org/10.3390/su4040703

Arnberger, A., & Brandenburg, C. (2007). Past on-site experience, crowding perceptions, and use displacement of visitor groups to a peri-urban national park. *Environmental Management*, *40*(1), 34–45. https://doi.org/10.1007/s00267-004-0355-8

ASReview LAB developers. (2023). *ASReview LAB - a tool for AI-assisted systematic reviews (v1.3a0)* [ASReview]. Retrieved July 6, 2023, from https://doi.org/10.5281/zenodo.3345592

Babí Almenar, J., Elliot, T., Rugani, B., Philippe, B., Navarrete Gutierrez, T., Sonnemann, G., & Geneletti, D. (2021). Nexus between nature-based solutions, ecosystem services and urban challenges. *Land Use Policy*, *100*, 104898. https://doi.org/10.1016/j.landusepol.2020.104898

Back, Y., Kumar, P., Bach, P., Rauch, W., & Kleidorfer, M. (2023). Integrating CFD-GIS modelling to refine urban heat and thermal comfort assessment. *Science of the Total Environment*, *858*. https://doi.org/10.1016/j.scitotenv.2022.159729

Bakhshoodeh, R., Ocampo, C., & Oldham, C. (2022). Exploring the evapotranspirative cooling effect of a green façade. *Sustainable Cities and Society*, *81*, 103822. https://doi.org/10.1016/j.scs.2022.103822

Barbosa, G., Drach, P., & Corbella, O. (2019). Intraurban temperature variations: Urban morphologies of the densification process of copacabana neighborhood, Brazil. *Climate*, *7*(5). https://doi.org/10.3390/cli7050065

Belcher, R., Suen, E., Menz, S., & Schroepfer, T. (2019). Shared landscapes increase condominium unit selling price in a high-density city. *Landscape and Urban Planning*, *192*. https://doi.org/10.1016/j.landurbplan.2019.103644

Bennett, J., Ogland-Hand, J., Middleton, E., Eidbo, J., Prorok, M., Ross, B., Yaw, S., & Middleton, R. (2023). The transmission ramifications of social and environmental siting considerations on wind energy deployment. *Frontiers in Energy Research*, *10*. https://doi.org/10.3389/fenrg.2022.1040957

Berghauser Pont, M., Haupt, P., Berg, P., Alstäde, V., & Heyman, A. (2021). Systematic review and comparison of densification effects and planning motivations. *Buildings and Cities*, *2*(1), 378. https://doi.org/10.5334/bc.125

Best, R., & Sinha, K. (2021). Fuel poverty policy: Go big or go home insulation. *Energy Economics*, *97*, 105195. https://doi.org/10.1016/j.eneco.2021.105195

Bhattacherjee, A. (2012). *Social science research: Principles, methods, and practices* [Open textbook library] [ISBN: 9781475146127]. Retrieved August 6, 2023, from https://open.umn.edu/opentextbooks/textbooks/79

Bianchini, F., & Hewage, K. (2012). Probabilistic social cost-benefit analysis for green roofs: A lifecycle approach. *Building and Environment*, *58*, 152–162. https://doi.org/10.1016/j.buildenv.2012.07.005

Bibri, S. E., Krogstie, J., & Kärrholm, M. (2020). Compact city planning and development: Emerging practices and strategies for achieving the goals of sustainability. *Developments in the Built Environment*, *4*, 100021. https://doi.org/10.1016/j.dibe.2020.100021

Bobylev, N. (2016). Underground space as an urban indicator: Measuring use of subsurface. *Tunnelling and Underground Space Technology*, *55*, 40–51. https://doi.org/10.1016/j.tust.2015.10.024

Böcker, L., van Amen, P., & Helbich, M. (2017). Elderly travel frequencies and transport mode choices in greater rotterdam, the netherlands. *Transportation*, *44*(4), 831–852. https://doi.org/10.1007/s11116-016-9680-z

Bok, J., & Kwon, Y. (2016). Comparable measures of accessibility to public transport using the general transit feed specification. *Sustainability (Switzerland)*, *8*(3). https://doi.org/10.3390/su8030224

Bouzarovski, S. (2014). Energy poverty in the european union: Landscapes of vulnerability [_eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1002/wene.89]. *WIREs Energy and Environment*, *3*(3), 276–289. https://doi.org/10.1002/wene.89

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology [Publisher: Routledge _eprint: https://www.tandfonline.com/doi/pdf/10.1191/1478088706qp063oa]. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Brindley, P., Jorgensen, A., & Maheswaran, R. (2018). Domestic gardens and self-reported health: A national population study. *International Journal of Health Geographics*, *17*(1), 31. https://doi.org/10.1186/s12942-018-0148-6

Brom, P., Engemann, K., Breed, C., Pasgaard, M., Onaolapo, T., & Svenning, J.-C. (2023). A decision support tool for green infrastructure planning in the face of rapid urbanization. *Land*, *12*(2). https://doi.org/10.3390/land12020415

Bruwier, M., Maravat, C., Mustafa, A., Teller, J., Pirotton, M., Erpicum, S., Archambeau, P., & Dewals, B. (2020). Influence of urban forms on surface flow in urban pluvial flooding. *Journal of Hydrology*, *582*. https://doi.org/10.1016/j.jhydrol.2019.124493

Burdge, R. J., & Vanclay, F. (1996). Social impact assessment: A contribution to the state of the art series. *Impact Assessment*, *14*(1), 59–86. https://doi.org/10.1080/07349165.1996.9725886

Butters, C., Cheshmehzangi, A., & Sassi, P. (2020). CITIES, ENERGY AND CLIMATE: SEVEN REASONS TO QUESTION THE DENSE HIGH-RISE CITY. *Journal of Green Building*, *15*(3), 197–214. https://doi.org/10.3992/jgb.15.3.197

Byrd, H., & Ho, A. (2012). Transport energy and city density: A case study of how renewable energy can reverse the curve. *Australas. Hous. Res. Conf., AHRC*. https://www.scopus.com/inward/record.uri?eid=2-s2.0-84875668863&partnerID=40&md5=f571c53300d16bb52ff3454ef8af6e51

Byrd, H., Ho, A., Sharp, B., & Kumar-Nair, N. (2013). Measuring the solar potential of a city and its implications for energy policy. *Energy Policy*, *61*, 944–952. https://doi.org/10.1016/j.enpol.2013.06.042

Byrne, J., Ambrey, C., Portanger, C., Lo, A., Matthews, T., Baker, D., & Davison, A. (2016). Could urban greening mitigate suburban thermal inequity?: The role of residents' dispositions and household practices. *Environmental Research Letters*, *11*(9). https://doi.org/10.1088/1748-9326/11/9/095014

C40 cities. (2023). *C40 cities - a global network of mayors taking urgent climate action* [C40 cities]. Retrieved September 2, 2023, from https://www.c40.org/

Campos, M. M., Warren, R., Birkmann, J., Luber, G., O'Neill, B., & Takahashi, K. (2014). *IPCC AR 5 chapter 19 — emergent risks and key vulnerabilities*.

Capitanescu, F. (2023). Are we prepared against blackouts during the energy transition?: Probabilistic risk-based decision making encompassing jointly security and resilience. *IEEE Power and Energy Magazine*, *21*(3), 77–86. https://doi.org/10.1109/MPE.2023.3247053

Castro-Carvajal, J. A., Patiño-Villada, F. A., Cardona-Rendón, B. M., & Ochoa- Patiño, V. (2008). Aspects associated with physical activity in the adult population's leisure time in a municipality in the antioquia department, colombia [Publisher: Universidad Nacional de Colombia]. *Revista de Salud Pública*, *10*(5), 679–690. Retrieved September 16, 2023, from http://www.scielo.org.co/scielo.php?script=sci_abstract&pid=S0124-00642008000500001&lng=en&nrm=iso&tlng=es

Cavicchia, R. (2023). Housing accessibility in densifying cities: Entangled housing and land use policy limitations and insights from oslo. *Land Use Policy*, *127*, 106580. https://doi.org/10.1016/j.landusepol.2023.106580

Cavicchia, R., & Cucca, R. (2020). Urban densification and its social sustainability. In *The palgrave encyclopedia of urban and regional futures* (pp. 1–14). Springer International Publishing. https://doi.org/10.1007/978-3-030-51812-7_156-1

Cea, L., & Costabile, P. (2022). Flood risk in urban areas: Modelling, management and adaptation to climate change. a review [Number: 3 Publisher: Multidisciplinary Digital Publishing Institute]. *Hydrology*, *9*(3), 50. https://doi.org/10.3390/hydrology9030050

Chakraborty, T., Hsu, A., Manya, D., & Sheriff, G. (2019). Disproportionately higher exposure to urban heat in lower-income neighborhoods: A multi-city perspective. *Environmental Research Letters*, *14*(10). https://doi.org/10.1088/1748-9326/ab3b99

Chaudhry, A.-G., Masoumi, H., & Dienel, H.-L. (2023). A systematic literature review of mobility attitudes and mode choices: MENA and south asian cities. *Frontiers in Sustainable Cities*, *4*. Retrieved August 28, 2023, from https://www.frontiersin.org/articles/10.3389/frsc.2022.1085784

Churchman, A. (1999). Disentangling the concept of density [Publisher: SAGE Publications Inc]. *Journal of Planning Literature*, *13*(4), 389–411. https://doi.org/10.1177/08854129922092478

Clark, T. (2013). Metropolitan density, energy efficiency and carbon emissions: Multi-attribute tradeoffs and their policy implications. *Energy Policy*, *53*, 413–428. https://doi.org/10.1016/j.enpol.2012.11.006

Crenshaw, K. (1989). Demarginalizing the intersection of race and sex: A black feminist critique of antidiscrimination doctrine, feminist theory and antiracist politics. *University of Chicago Legal Forum*, *1989*, 139. https://heinonline.org/HOL/Page?handle=hein.journals/uchclf1989&id=143&div=&collection=

Crenshaw, K. (1990). Mapping the margins: Intersectionality, identity politics, and violence against women of color. *Stanford Law Review*, *43*, 1241. https://heinonline.org/HOL/Page?handle=hein.journals/stflr43&id=1257&div=&collection=

Cundill, G., Singh, C., Adger, W. N., Safra de Campos, R., Vincent, K., Tebboth, M., & Maharjan, A. (2021). Toward a climate mobilities research agenda: Intersectionality, immobility, and policy responses. *Global Environmental Change*, *69*, 102315. https://doi.org/10.1016/j.gloenvcha.2021.102315

Cutts, B. B., Darby, K. J., Boone, C. G., & Brewis, A. (2009). City structure, obesity, and environmental justice: An integrated analysis of physical and social barriers to walkable streets and park access. *Social Science & Medicine*, *69*(9), 1314–1322. https://doi.org/10.1016/j.socscimed.2009.08.020

Dai, D. (2011). Racial/ethnic and socioeconomic disparities in urban green space accessibility: Where to intervene? *Landscape and Urban Planning*, *102*(4), 234–244. https://doi.org/10.1016/j.landurbplan.2011.05.002

D'Aragon, J. (2013). Disaster risk reduction and resilience building of urban poor communities. *Regional Development Dialogue*, *34*, 1–18.

Delgado-Capel, M., & Cariñanos, P. (2020). Towards a standard framework to identify green infrastructure key elements in dense mediterranean cities. *Forests*, *11*(12), 1–22. https://doi.org/10.3390/f11121246

Dempsey, N. (2008). Quality of the built environment in urban neighbourhoods [Publisher: Routledge _eprint: https://doi.org/10.1080/02697450802327198]. *Planning Practice & Research*, *23*(2), 249–264. https://doi.org/10.1080/02697450802327198

Deng, X., Cao, Q., Wang, L., Wang, W., Wang, S., Wang, S., & Wang, L. (2023). Characterizing urban densification and quantifying its effects on urban thermal environments and human thermal comfort. *Landscape and Urban Planning*, *237*. https://doi.org/10.1016/j.landurbplan.2023.104803

Ditton, R. B., Fedler, A. J., & Graefe, A. R. (1983). Factors contributing to perceptions of recreational crowding [Publisher: Routledge _eprint: https://doi.org/10.1080/01490408309513009]. *Leisure Sciences*, *5*(4), 273–288. https://doi.org/10.1080/01490408309513009

Djekic, J., Djukic, A., Vukmirovic, M., Djekic, P., & Dinic Brankovic, M. (2018). Thermal comfort of pedestrian spaces and the influence of pavement materials on warming up during summer. *Energy and Buildings*, *159*, 474–485. https://doi.org/10.1016/j.enbuild.2017.11.004

Doughnut Economics Action Lab (DEAL), Biomimicry 3.8, Circle Economy, & C40 cities. (2020, March). The amsterdam city doughnut. a tool for transformative action. https://doughnuteconomics.org/amsterdam-portrait.pdf

Du, M., & Zhang, X. (2020). Urban greening: A new paradox of economic or social sustainability? *Land Use Policy*, *92*. https://doi.org/10.1016/j.landusepol.2020.104487

Du, M., Zhang, X., & Mora, L. (2021). Strategic planning for smart city development: Assessing spatial inequalities in the basic service provision of metropolitan cities. *Journal of Urban Technology*, *28*(1), 115–134. https://doi.org/10.1080/10630732.2020.1803715

Duy, P., Chapman, L., Tight, M., Linh, P., & Thuong, L. (2018). Increasing vulnerability to floods in new development areas: Evidence from Ho Chi Minh City. *International Journal of Climate Change Strategies and Management*, *10*(1), 197–212. https://doi.org/10.1108/IJCCSM-12-2016-0169

Enander, A. E., & Hygge, S. (1990). Thermal stress and human performance [Publisher: Scandinavian Journal of Work, Environment & Health]. *Scandinavian Journal of Work, Environment & Health*, *16*, 44–50. Retrieved August 28, 2023, from http://www.jstor.org/stable/40965843

Ergas, C., McKinney, L., & Bell, S. E. (2021). Intersectionality and the environment. In B. Schaefer Caniglia, A. Jorgenson, S. A. Malin, L. Peek, D. N. Pellow, & X. Huang (Eds.), *Handbook of environmental sociology* (pp. 15–34). Springer International Publishing. https://doi.org/10.1007/978-3-030-77712-8_2

Erlwein, S., Meister, J., Wamsler, C., & Pauleit, S. (2023). Governance of densification and climate change adaptation: How can conflicting demands for housing and greening in cities be reconciled? *Land Use Policy*, *128*. https://doi.org/10.1016/j.landusepol.2023.106593

Erlwein, S., & Pauleit, S. (2021). Trade-offs between urban green space and densification: Balancing outdoor thermal comfort, mobility, and housing demand. *Urban Planning*, *6*(1), 5–19. https://doi.org/10.17645/UP.V6I1.3481

European Commission - Competence Centere on Foresight. (2020). *Developments and forecasts on continuing urbanisation* [Competence centre on foresight]. https://knowledge4policy.ec.europa.eu/foresight/topic/continuing-urbanisation/developments-and-forecasts-on-continuing-urbanisation_en

European Commission-Joint Research Centre. (2023). *The future of cities* [European commission]. Retrieved September 2, 2023, from https://urban.jrc.ec.europa.eu/thefutureofcities/

Everett, G., Lamond, J., Morzillo, A., Matsler, A., & Chan, F. (2018). Delivering Green Streets: An exploration of changing perceptions and behaviours over time around bioswales in Portland, Oregon [_eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/jfr3.12225]. *Journal of Flood Risk Management*, *11*(S2), S973–S985. https://doi.org/10.1111/jfr3.12225

Filho, W., Al-Amin, A., Nagy, G., Azeiteiro, U., Wiesböck, L., Ayal, D., Morgan, E., Mugabe, P., Aparicio-Effen, M., Fudjumdjum, H., & Jabbour, C. (2018). A comparative analysis of climate-risk and extreme event-related impacts on well-being and health: Policy implications. *International Journal of Environmental Research and Public Health*, *15*(2). https://doi.org/10.3390/ijerph15020331

Fitobór, K., Ulańczyk, R., Kołecka, K., Ramm, K., Włodarek, I., Zima, P., Kalinowska, D., Wielgat, P., Mikulska, M., Antończyk, D., Krzaczkowski, K., Łyszyk, R., & Gajewska, M. (2022). Extreme weather layer method for implementation of nature-based solutions for climate adaptation: Case study Słupsk. *Science of the Total Environment*, *842*. https://doi.org/10.1016/j.scitotenv.2022.156751

Foshag, K., Aeschbach, N., Höfle, B., Winkler, R., Siegmund, A., & Aeschbach, W. (2020). Viability of public spaces in cities under increasing heat: A transdisciplinary approach. *Sustainable Cities and Society*, *59*, 102215. https://doi.org/10.1016/j.scs.2020.102215

Francis, J., Giles-Corti, B., Wood, L., & Knuiman, M. (2012). Creating sense of community: The role of public space. *Journal of Environmental Psychology*, *32*(4), 401–409. https://doi.org/10.1016/j.jenvp.2012.07.002

Fuller, R. A., Irvine, K. N., Devine-Wright, P., Warren, P. H., & Gaston, K. J. (2007). Psychological benefits of greenspace increase with biodiversity [Publisher: Royal Society]. *Biology Letters*, *3*(4), 390–394. https://doi.org/10.1098/rsbl.2007.0149

Furszyfer Del Rio, J., Furszyfer Del Rio, D. D., Sovacool, B. K., & Griffiths, S. (2023). The demographics of energy and mobility poverty: Assessing equity and justice in ireland, mexico, and the united arab emirates. *Global Environmental Change*, *81*, 102703. https://doi.org/10.1016/j.gloenvcha.2023.102703

Gadish, I., Saaroni, H., & Pearlmutter, D. (2023). A predictive analysis of thermal stress in a densifying urban business district under summer daytime conditions in a mediterranean city. *Urban Climate*, *48*. https://doi.org/10.1016/j.uclim.2022.101298

Gemeente Amsterdam. (2021). *Strategisch plan Sporten en Spelen in openbare ruimte* [openresearch.amsterdam]. Retrieved October 5, 2023, from https://openresearch.amsterdam/nl/page/72531/strategisch-plan-sporten-en-spelen-in-openbare-ruimte

Gemeente Amsterdam. (2023a). *Dashboard kerncijfers* [| Website Onderzoek en Statistiek]. Retrieved September 25, 2023, from https://onderzoek.amsterdam.nl/interactief/kerncijfers?tab=gebied&thema=overzicht&gebied=STAD&taal=nl

Gemeente Amsterdam. (2023b). *Dit moet er gebeuren* [Amsterdam.nl] [Last Modified: 2023-09-26 Publisher: Gemeente Amsterdam]. Retrieved September 26, 2023, from https://www.amsterdam.nl/wonen-leefomgeving/elektriciteitsvoorziening-amsterdam/dit-moet-gebeuren/

Gemeente Amsterdam. (2023c). Onze stad van morgen. https://www.amsterdam.nl/wonen-leefomgeving/duurzaam-amsterdam/publicaties-duurzaam-groen/onze-stad-morgen/?PagClsIdt=17311563#PagCls_17311563

Gemeente Amsterdam. (2023d). *Policy: Circular economy* [English site] [Last Modified: 2023-10-03 Publisher: Gemeente Amsterdam]. Retrieved October 5, 2023, from https://www.amsterdam.nl/en/policy/sustainability/circular-economy/

Gemeente Amsterdam. (2023e). *Sluisbuurt op Zeeburgereiland: 5.500 nieuwe woningen* [Amsterdam.nl] [Last Modified: 2023-09-21 Publisher: Gemeente Amsterdam]. Retrieved September 25, 2023, from https://www.amsterdam.nl/projecten/sluisbuurt/

Gemeente Amsterdam. (2023f). *Volg het beleid: duurzaamheid* [Amsterdam.nl] [Last Modified: 2023-09-25 Publisher: Gemeente Amsterdam]. Retrieved September 25, 2023, from https://www.amsterdam.nl/bestuur-organisatie/volg-beleid/duurzaamheid/

Gemeente Amsterdam. (2023g). *Volg het beleid: economie* [Amsterdam.nl] [Last Modified: 2023-09-25 Publisher: Gemeente Amsterdam]. Retrieved September 25, 2023, from https://www.amsterdam.nl/bestuur-organisatie/volg-beleid/economie/

Gemeente Amsterdam. (2023h). *Volg het beleid: groen* [Amsterdam.nl] [Last Modified: 2023-09-24 Publisher: Gemeente Amsterdam]. Retrieved September 26, 2023, from https://www.amsterdam.nl/bestuur-organisatie/volg-beleid/groen/

Gemeente Amsterdam. (2023i). *Volg het beleid: omgevingsvisie* [Amsterdam.nl] [Last Modified: 2023-09-15 Publisher: Gemeente Amsterdam]. Retrieved September 25, 2023, from https://www.amsterdam.nl/bestuur-organisatie/volg-beleid/stedelijke-ontwikkeling/

Gemeente Amsterdam. (2023j). *Volg het beleid: Verkeer en vervoer* [Amsterdam.nl] [Last Modified: 2023-09-25 Publisher: Gemeente Amsterdam]. Retrieved September 26, 2023, from https://www.amsterdam.nl/bestuur-organisatie/volg-beleid/verkeer-vervoer/

Gemeente Amsterdam. (2023k, August 5). Startnotitie ontwikkelstrateggie 2035. https://assets.amsterdam.nl/publish/pages/1032357/startnotitie_ontwikkelstrategie_2035_.pdf

Gemeente Amsterdam - Verkeer en Openbare Ruimte. (2015, October). *Uitvoeringsagenda mobiliteit*. Retrieved September 26, 2023, from https://www.amsterdam.nl/bestuur-organisatie/volg-beleid/verkeer-vervoer/uitvoeringsagenda/?PagClsIdt=14809443#PagCls_14809443

Gemeente Rotterdam. (2023). *Omgevingsvisie Rotterdam* [Gemeente Rotterdam]. Retrieved September 11, 2023, from https://www.rotterdam.nl/omgevingsvisie-waarom

Ghisellini, P., Passaro, R., & Ulgiati, S. (2023). Environmental assessment of multiple "cleaner electricity mix" scenarios within just energy and circular economy transitions, in italy and europe. *Journal of Cleaner Production*, *388*. https://doi.org/10.1016/j.jclepro.2023.135891

Gil Solá, A. (2016). Constructing work travel inequalities: The role of household gender contracts. *Journal of Transport Geography*, *53*, 32–40. https://doi.org/10.1016/j.jtrangeo.2016.04.007

Goel, R. (2023). Gender gap in mobility outside home in urban india. *Travel Behaviour and Society*, *32*, 100559. https://doi.org/10.1016/j.tbs.2023.01.004

Großmann, K., Buchholz, J., Buchmann, C., Hedtke, C., Höhnke, C., & Schwarz, N. (2014). Energy costs, residential mobility, and segregation in a shrinking city. *Open House International*, *39*(2), 14–24.

Grunwald, L., & Weber, S. (2021). Influence of urban land-use change on cold-air path occurrence and spatial distribution. *Computational Urban Science*, *1*(1), 25. https://doi.org/10.1007/s43762-021-00026-7

Guetterman, T., & Fetters, M. (2018). Two methodological approaches to the integration of mixed methods and case study designs: A systematic review. *American Behavioral Scientist*, *62*(7), 900–918. https://doi.org/10.1177/0002764218772641

Gunton, T., & Day, J. (2003). The theory and practice of collaborative planning in resource and environmental management. *Environments*, *31*(2), 5–20.

Guzman, L., Oviedo, D., & Rivera, C. (2017). Assessing equity in transport accessibility to work and study: The bogotá region. *Journal of Transport Geography*, *58*, 236–246. https://doi.org/10.1016/j.jtrangeo.2016.12.016

Haaland, C., & van den Bosch, C. K. (2015). Challenges and strategies for urban green-space planning in cities undergoing densification: A review. *Urban Forestry & Urban Greening*, *14*(4), 760–771. https://doi.org/10.1016/j.ufug.2015.07.009

Haarstad, H., Kjærås, K., Røe, P. G., & Tveiten, K. (2023). Diversifying the compact city: A renewed agenda for geographical research. *Dialogues in Human Geography*, *13*(1), 5–24. https://doi.org/10.1177/20438206221102949

Haberl, H., Schmid, M., Haas, W., Wiedenhofer, D., Rau, H., & Winiwarter, V. (2021). Stocks, flows, services and practices: Nexus approaches to sustainable social metabolism. *Ecological Economics*, *182*, 106949. https://doi.org/10.1016/j.ecolecon.2021.106949

Habitat III Secretariat. (2017). *Glossary of the habitat III* [Habitat III]. Retrieved May 24, 2023, from https://habitat3.org/documents-and-archive/new-urban-agenda/glossary/

Harlan, Sharon L, Pellow, David N, & Timmons Roberts, J. (2015). Climate justice and inequality [Google-Books-ID: kjlKCgAAQBAJ]. In R. E. Dunlap & R. J. Brulle (Eds.), *Climate change and society: Sociological perspectives*. Oxford University Press.

Heyen, D. A. (2023). Social justice in the context of climate policy: Systematizing the variety of inequality dimensions, social impacts, and justice principles [Publisher: Taylor & Francis _eprint: https://doi.org/10.1080/14693062.2022.2142499]. *Climate Policy*, *23*(5), 539–554. https://doi.org/10.1080/14693062.2022.2142499

Hoshiko, T., Nakajima, F., Prueksasit, T., & Yamamoto, K. (2012). Health risk of exposure to vehicular emissions in wind-stagnant street canyons. In S. Kato & K. Hiyama (Eds.), *Ventilating cities: Air-flow criteria for healthy and comfortable urban living* (pp. 59–95). Springer Netherlands. https://doi.org/10.1007/978-94-007-2771-7_4

Hosseini, M., Javanroodi, K., & Nik, V. M. (2022). High-resolution impact assessment of climate change on building energy performance considering extreme weather events and microclimate – investigating variations in indoor thermal comfort and degree-days. *Sustainable Cities and Society*, *78*, 103634. https://doi.org/10.1016/j.scs.2021.103634

Howden-Chapman, P., Bennett, J., Edwards, R., Jacobs, D., Nathan, K., & Ormandy, D. (2023). Review of the impact of housing quality on inequalities in health and well-being. *Annual Review of Public Health*, *44*, 233–254. https://doi.org/10.1146/annurev-publhealth-071521-111836

Hughes, T. P. (1989). The evolution of large technological systems [Google-Books-ID: SUCtOwns7TEC]. In *The social construction of technological systems: New directions in the sociology and history of technology* (pp. 51–82). MIT Press.

Ignatieva, M., & Mofrad, F. (2023). Understanding urban green spaces typology's contribution to comprehensive green infrastructure planning: A study of canberra, the national capital of australia. *Land*, *12*(5). https://doi.org/10.3390/land12050950

Imperiale, A., & Vanclay, F. (2023). Re-designing social impact assessment to enhance community resilience for disaster risk reduction, climate action and sustainable development. *Sustainable Development*. https://doi.org/10.1002/sd.2690

International Energy Association (IEA). (2021). *Renewables – global energy review 2021 – analysis* [IEA]. Retrieved September 11, 2023, from https://www.iea.org/reports/global-energy-review-2021/renewables

International Society for Industrial Ecology. (2023). *What is industrial ecology?* https://is4ie.org/about/what-is-industrial-ecology

Jamei, E., Rajagopalan, P., Seyedmahmoudian, M., & Jamei, Y. (2016). Review on the impact of urban geometry and pedestrian level greening on outdoor thermal comfort. *Renewable and Sustainable Energy Reviews*, *54*, 1002–1017. https://doi.org/10.1016/j.rser.2015.10.104

Javidroozi, V., Carter, C., Grace, M., & Shah, H. (2023). Smart, sustainable, green cities: A state-of-the-art review. *Sustainability*, *15*(6), 5353. https://doi.org/10.3390/su15065353

Jennings, V., Larson, L., & Yun, J. (2016). Advancing sustainability through urban green space: Cultural ecosystem services, equity, and social determinants of health. *International Journal of Environmental Research and Public Health*, *13*(2). https://doi.org/10.3390/ijerph13020196

Joensuu, T., Edelman, H., & Saari, A. (2020). Circular economy practices in the built environment. *Journal of Cleaner Production*, *276*, 124215. https://doi.org/10.1016/j.jclepro.2020.124215

Johnson, A. M., & Miles, R. (2014). Toward more inclusive public spaces: Learning from the everyday experiences of muslim arab women in new york city [Publisher: SAGE Publications Ltd]. *Environment and Planning A: Economy and Space*, *46*(8), 1892–1907. https://doi.org/10.1068/a46292

Jose, R. S., Pérez, J. L., & Gonzalez-Barras, R. M. (2021). Multizone airflow and pollution simulations of indoor emission sources. *Science of The Total Environment*, *766*, 142593. https://doi.org/10.1016/j.scitotenv.2020.142593

Juntti, M., & Ozsezer-Kurnuc, S. (2023). Factors influencing the realisation of the social impact of urban nature in inner-city environments: A systematic review of complex evidence. *Ecological Economics*, *211*. https://doi.org/10.1016/j.ecolecon.2023.107872

Kabisch, N., Kraemer, R., Brenck, M. E., Haase, D., Lausch, A., Luttkus, M. L., Mueller, T., Remmler, P., von Döhren, P., Voigtländer, J., & Bumberger, J. (2021). A methodological framework for the assessment of regulating and recreational ecosystem services in urban parks under heat and drought conditions [Publisher: Taylor & Francis _eprint: https://doi.org/10.1080/26395916.2021.1958062]. *Ecosystems and People*, *17*(1), 464–475. https://doi.org/10.1080/26395916.2021.1958062

Kabisch, N., Frantzeskaki, N., Pauleit, S., Naumann, S., Davis, M., Artmann, M., Haase, D., Knapp, S., Korn, H., Stadler, J., Zaunberger, K., & Bonn, A. (2016). Nature-based solutions to climate change mitigation and adaptation in urban areas: Perspectives on indicators, knowledge gaps, barriers, and opportunities for action [Publisher: Resilience Alliance Inc.]. *Ecology and Society*, *21*(2). Retrieved September 9, 2023, from https://www.jstor.org/stable/26270403

Kaijser, A., & Kronsell, A. (2014). Climate change through the lens of intersectionality [Publisher: Routledge _eprint: https://doi.org/10.1080/09644016.2013.835203]. *Environmental Politics*, *23*(3), 417–433. https://doi.org/10.1080/09644016.2013.835203

Kang, S., Lee, D., Park, J., & Jung, J. (2022). Exploring urban forms vulnerable to urban heat islands: A multiscale analysis [Number: 6 Publisher: Multidisciplinary Digital Publishing Institute]. *Sustainability*, *14*(6), 3603. https://doi.org/10.3390/su14063603

Kaukinen, C. (2020). When stay-at-home orders leave victims unsafe at home: Exploring the risk and consequences of intimate partner violence during the COVID-19 pandemic. *American Journal of Criminal Justice*, *45*(4), 668–679. https://doi.org/10.1007/s12103-020-09533-5

Kaza, N. (2020). Urban form and transportation energy consumption. *Energy Policy*, *136*. https://doi.org/10.1016/j.enpol.2019.111049

Kennedy, C. A., Stewart, I., Facchini, A., Cersosimo, I., Mele, R., Chen, B., Uda, M., Kansal, A., Chiu, A., Kim, K.-g., Dubeux, C., Lebre La Rovere, E., Cunha, B., Pincetl, S., Keirstead, J., Barles, S., Pusaka, S., Gunawan, J., Adegbile, M., . . . Sahin, A. D. (2015). Energy and material flows of megacities [Publisher: Proceedings of the National Academy of Sciences]. *Proceedings of the National Academy of Sciences*, *112*(19), 5985–5990. https://doi.org/10.1073/pnas.1504315112

Khavarian-Garmsir, A. R., Sharifi, A., & Moradpour, N. (2021). Are high-density districts more vulnerable to the COVID-19 pandemic? *Sustainable Cities and Society*, *70*, 102911. https://doi.org/10.1016/j.scs.2021.102911

Kii, M. (2020). Reductions in CO2 emissions from passenger cars under demography and technology scenarios in japan by 2050. *Sustainability (Switzerland)*, *12*(17). https://doi.org/10.3390/SU12176919

Kleerekoper, L., van den Dobbelsteen, A., Hordijk, G., van Dorst, M., & Martin, C. (2015). Climate adaptation strategies: Achieving insight in microclimate effects of redevelopment options. *Smart and Sustainable Built Environment*, *4*(1), 110–136. https://doi.org/10.1108/SASBE-08-2014-0045

Knapskog, M., Hagen, O. H., Tennøy, A., & Rynning, M. K. (2019). Exploring ways of measuring walkability. *Transportation Research Procedia*, *41*, 264–282. https://doi.org/10.1016/j.trpro.2019.09.047

Knott, E., Hamid Rao, A., Summers, K., & Teeger, C. (2022). Interviews in the social sciences. *Nature*, *2*(73). Retrieved June 21, 2023, from https://www.nature.com/articles/s43586-022-00150-6

Ko, Y., Jang, K., & Radke, J. D. (2017). Toward a solar city: Trade-offs between on-site solar energy potential and vehicle energy consumption in san francisco, california [Publisher: Taylor & Francis _eprint: https://doi.org/10.1080/15568318.2016.1274807]. *International Journal of Sustainable Transportation*, *11*(6), 460–470. https://doi.org/10.1080/15568318.2016.1274807

Kolimenakis, A., Solomou, A., Proutsos, N., Avramidou, E., Korakaki, E., Karetsos, G., Maroulis, G., Papagiannis, E., & Tsagkari, K. (2021). The socioeconomic welfare of urban green areas and parks; a literature review of available evidence. *Sustainability (Switzerland)*, *13*(14). https://doi.org/10.3390/su13147863

Kolokotsa, D., & Santamouris, M. (2015). Review of the indoor environmental quality and energy consumption studies for low income households in europe. *Science of the Total Environment*, *536*, 316–330. https://doi.org/10.1016/j.scitotenv.2015.07.073

Kourtis, I., & Tsihrintzis, V. (2021). Adaptation of urban drainage networks to climate change: A review. *Science of the Total Environment*, *771*. https://doi.org/10.1016/j.scitotenv.2021.145431

Koutra, S., Becue, V., Gallas, M.-A., & Ioakimidis, C. S. (2018). Towards the development of a net-zero energy district evaluation approach: A review of sustainable approaches and assessment tools. *Sustainable Cities and Society*, *39*, 784–800. https://doi.org/10.1016/j.scs.2018.03.011

Kuran, C. H. A., Morsut, C., Kruke, B. I., Krüger, M., Segnestam, L., Orru, K., Nævestad, T. O., Airola, M., Keränen, J., Gabel, F., Hansson, S., & Torpan, S. (2020). Vulnerability and vulnerable groups from an intersectionality perspective. *International Journal of Disaster Risk Reduction*, *50*, 101826. https://doi.org/10.1016/j.ijdrr.2020.101826

Lan, L., Lian, Z., & Pan, L. (2010). The effects of air temperature on office workers' well-being, workload and productivity-evaluated with subjective ratings. *Applied Ergonomics*, *42*(1), 29–36. https://doi.org/10.1016/j.apergo.2010.04.003

Larimian, T., & Sadeghi, A. (2021). Measuring urban social sustainability: Scale development and validation [Publisher: SAGE Publications Ltd STM]. *Environment and Planning B: Urban Analytics and City Science*, *48*(4), 621–637. https://doi.org/10.1177/2399808319882950

Latasa, I., & Laurenz, A. (2023). The residual spaces of developmental urbanism as opportunity for green cities and improvement of human wellbeing. *Land*, *12*(4), 764. https://doi.org/10.3390/land12040764

Lauria, A. (2023). Green spaces and public health in urban contexts. In S. Capolongo, M. Botta, & A. Rebecchi (Eds.), *Therapeutic landscape design: Methods, design strategies and new scientific approaches* (pp. 93–99). Springer International Publishing. https://doi.org/10.1007/978-3-031-09439-2_9

Lehmann, S. (2019). Understanding and quantifying urban density toward more sustainable city form. In L. D'Acci (Ed.), *The mathematics of urban morphology* (pp. 547–556). Springer International Publishing. https://doi.org/10.1007/978-3-030-12381-9_30

Lemonsu, A., Viguié, V., Daniel, M., & Masson, V. (2015). Vulnerability to heat waves: Impact of urban expansion scenarios on urban heat island and heat stress in paris (france). *Urban Climate*, *14*, 586–605. https://doi.org/10.1016/j.uclim.2015.10.007

Lenton, T. M., Xu, C., Abrams, J. F., Ghadiali, A., Loriani, S., Sakschewski, B., Zimm, C., Ebi, K. L., Dunn, R. R., Svenning, J.-C., & Scheffer, M. (2023). Quantifying the human cost of global warming [Publisher: Nature Publishing Group]. *Nature Sustainability*, 1–11. https://doi.org/10.1038/s41893-023-01132-6

Levesque, A. R., MacDonald, S., Berg, S. A., & Reka, R. (2021). Assessing the impact of changes in household socioeconomic status on the health of children and adolescents: A systematic review. *Adolescent Research Review*, *6*(2), 91–123. https://doi.org/10.1007/s40894-021-00151-8

Levine, J. (2017). The paradox of community power: Cultural processes and elite authority in participatory governance. *Social Forces*, *95*(3), 1155–1179. https://doi.org/10.1093/sf/sow098

Li, X., Erpicum, S., Mignot, E., Archambeau, P., Pirotton, M., & Dewals, B. (2021). Influence of urban forms on long-duration urban flooding: Laboratory experiments and computational analysis. *Journal of Hydrology*, *603*. https://doi.org/10.1016/j.jhydrol.2021.127034

Liu, L., He, G., Wu, M., Liu, G., Zhang, H., Chen, Y., Shen, J., & Li, S. (2023). Climate change impacts on planned supply–demand match in global wind and solar energy systems. *Nature Energy*. https://doi.org/10.1038/s41560-023-01304-w

Liu, X., & Sweeney, J. (2012). Modelling the impact of urban form on household energy demand and related CO2 emissions in the greater dublin region. *Energy Policy*, *46*, 359–369. https://doi.org/10.1016/j.enpol.2012.03.070

Liu, Z., Li, L., Wang, S., & Wang, X. (2022). Optimal design of low-carbon energy systems towards sustainable cities under climate change scenarios. *Journal of Cleaner Production*, *366*, 132933. https://doi.org/10.1016/j.jclepro.2022.132933

Loibl, W., Vuckovic, M., Etminan, G., Ratheiser, M., Tschannett, S., & Österreicher, D. (2021). Effects of densification on urban microclimate—a case study for the city of vienna. *Atmosphere*, *12*(4). https://doi.org/10.3390/atmos12040511

Lord, S., Després, C., & Ramadier, T. (2011). When mobility makes sense: A qualitative and longitudinal study of the daily mobility of the elderly. *Journal of Environmental Psychology*, *31*(1), 52–61. https://doi.org/10.1016/j.jenvp.2010.02.007

Lund, N. S. V., Borup, M., Madsen, H., Mark, O., Arnbjerg-Nielsen, K., & Mikkelsen, P. S. (2019). Integrated stormwater inflow control for sewers and green structures in urban landscapes [Number: 11 Publisher: Nature Publishing Group]. *Nature Sustainability*, *2*(11), 1003–1010. https://doi.org/10.1038/s41893-019-0392-1

Lundgren Kownacki, K., Gao, C., Kuklane, K., & Wierzbicka, A. (2019). Heat stress in indoor environments of scandinavian urban areas: A literature review [Number: 4 Publisher: Multidisciplinary Digital Publishing Institute]. *International Journal of Environmental Research and Public Health*, *16*(4), 560. https://doi.org/10.3390/ijerph16040560

Machairas, I., & van de Ven, F. H. M. (2023). An urban drought categorization framework and the vulnerability of a lowland city to groundwater urban droughts. *Natural Hazards*, *116*(2), 1403–1431. https://doi.org/10.1007/s11069-022-05767-0

Malin, S. A., & Ryder, S. S. (2018). Developing deeply intersectional environmental justice scholarship [Publisher: Routledge _eprint: https://doi.org/10.1080/23251042.2018.1446711]. *Environmental Sociology*, *4*(1), 1–7. https://doi.org/10.1080/23251042.2018.1446711

Maller, C. J., & Strengers, Y. (2011). Housing, heat stress and health in a changing climate: Promoting the adaptive capacity of vulnerable households, a suggested way forward. *Health Promotion International*, *26*(4), 492–498. https://doi.org/10.1093/heapro/dar003

Marroquín, B., Vine, V., & Morgan, R. (2020). Mental health during the COVID-19 pandemic: Effects of stay-at-home policies, social distancing behavior, and social resources. *Psychiatry Research*, *293*, 113419. https://doi.org/10.1016/j.psychres.2020.113419

Martilli, A. (2014). An idealized study of city structure, urban climate, energy consumption, and air quality. *Urban Climate*, *10*, 430–446. https://doi.org/10.1016/j.uclim.2014.03.003

Martínez Reverte, I., Gómez-Navarro, T., Sánchez-Díaz, C., & Montagud Montalvá, C. (2022). Evaluation of Alternatives for Energy Supply from Fuel Cells in Compact Cities in the Mediterranean Climate; Case Study: City of Valencia [Number: 12 Publisher: Multidisciplinary Digital Publishing Institute]. *Energies*, *15*(12), 4502. https://doi.org/10.3390/en15124502

Mauree, D., Naboni, E., Coccolo, S., Perera, A. T. D., Nik, V. M., & Scartezzini, J.-L. (2019). A review of assessment methods for the urban environment and its energy sustainability to guarantee climate adaptation of future cities. *Renewable and Sustainable Energy Reviews*, *112*, 733–746. https://doi.org/10.1016/j.rser.2019.06.005

Mazumdar, S., Learnihan, V., Cochrane, T., & Davey, R. (2018). The built environment and social capital: A systematic review [Publisher: SAGE Publications Inc]. *Environment and Behavior*, *50*(2), 119–158. https://doi.org/10.1177/0013916516687343

McGregor, G., & Ren, C. (2021). Urban climate science for planning healthy cities. In C. Ren & G. McGregor (Eds.), *Urban climate science for planning healthy cities* (pp. 3–16). Springer International Publishing. https://doi.org/10.1007/978-3-030-87598-5_1

McIntosh, M. J., & Morse, J. M. (2015). Situating and constructing diversity in semi-structured interviews [Publisher: SAGE Publications Inc]. *Global Qualitative Nursing Research*, *2*, 2333393615597674. https://doi.org/10.1177/2333393615597674

Mears, M., Brindley, P., Maheswaran, R., & Jorgensen, A. (2019). Understanding the socioeconomic equity of publicly accessible greenspace distribution: The example of sheffield, UK. *Geoforum*, *103*, 126–137. https://doi.org/10.1016/j.geoforum.2019.04.016

Mehrotra, S., Bardhan, R., & Ramamritham, K. (2018). Urban informal housing and surface urban heat island intensity: Exploring spatial association in the city of mumbai [Publisher: SAGE Publications India]. *Environment and Urbanization ASIA*, *9*(2), 158–177. https://doi.org/10.1177/0975425318783548

Metropoolregion Amsterdam. (2023). *Over de Metropoolregio Amsterdam* [metropoolregioamsterdam]. Retrieved September 25, 2023, from https://www.metropoolregioamsterdam.nl/over-mra/

Mielby, S., & Henriksen, H. (2020). Hydrogeological studies integrating the climate, freshwater cycle, and catchment geography for the benefit of urban resilience and sustainability. *Water (Switzerland)*, *12*(12). https://doi.org/10.3390/w12123324

Mielck, A., & Heinrich, J. (2002). Soziale Ungleichheit und die Verteilung umweltbezogener Expositionen (Environmental Justice) [Publisher: © Georg Thieme Verlag Stuttgart · New York]. *Das Gesundheitswesen*, *64*(7), 405–416. https://doi.org/10.1055/s-2002-32815

Miner, M. J., Taylor, R. A., Jones, C., & Phelan, P. E. (2017). Efficiency, economics, and the urban heat island [Publisher: SAGE Publications Ltd]. *Environment and Urbanization*, *29*(1), 183–194. https://doi.org/10.1177/0956247816655676

Ministerie van Binnenlandse Zaken en Koninkrijksrelaties. (2020). *De Nationale Omgevingsvisie* [Ontwerp NOVI]. Retrieved May 24, 2023, from https://www.novistukken.nl/de+novi/default.aspx

Mitchell, B. C., & Chakraborty, J. (2015). Landscapes of thermal inequity: Disproportionate exposure to urban heat in the three largest US cities [Publisher: IOP Publishing]. *Environmental Research Letters*, *10*(11), 115005. https://doi.org/10.1088/1748-9326/10/11/115005

Mitchell, B. C., & Chakraborty, J. (2014). Urban heat and climate justice: A landscape of thermal inequity in pinellas county, florida [Publisher: Routledge _eprint: https://doi.org/10.1111/j.1931-0846.2014.12039.x]. *Geographical Review*, *104*(4), 459–480. https://doi.org/10.1111/j.1931-0846.2014.12039.x

Mobini, S., Becker, P., Larsson, R., & Berndtsson, R. (2020). Systemic inequity in urban flood exposure and damage compensation [Number: 11 Publisher: Multidisciplinary Digital Publishing Institute]. *Water*, *12*(11), 3152. https://doi.org/10.3390/w12113152

Mohajeri, N., Perera, A. T. D., Coccolo, S., Mosca, L., Le Guen, M., & Scartezzini, J.-L. (2019). Integrating urban form and distributed energy systems: Assessment of sustainable development scenarios for a swiss village to 2050. *Renewable Energy*, *143*, 810–826. https://doi.org/10.1016/j.renene.2019.05.033

Mohajeri, N., Walch, A., Smith, A., Gudmundsson, A., Assouline, D., Russell, T., & Hall, J. (2023). A machine learning methodology to quantify the potential of urban densification in the oxford-cambridge arc, united kingdom. *Sustainable Cities and Society*, *92*, 104451. https://doi.org/10.1016/j.scs.2023.104451

Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2010). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *International Journal of Surgery*, *8*(5), 336–341. https://doi.org/10.1016/j.ijsu.2010.02.007

Moore, T., Ridley, I., Strengers, Y., Maller, C., & Horne, R. (2017). Dwelling performance and adaptive summer comfort in low-income australian households. *Building Research and Information*, *45*(4), 443–456. https://doi.org/10.1080/09613218.2016.1139906

Moravej, M., Renouf, M., Kenway, S., & Urich, C. (2022). What roles do architectural design and on-site water servicing technologies play in the water performance of residential infill? *Water Research*, *213*. https://doi.org/10.1016/j.watres.2022.118109

Morelli, A., & Cunha, A. (2021). Measuring urban road network vulnerability to extreme events: An application for urban floods [Publisher: Elsevier Ltd]. *Transportation Research Part D: Transport and Environment*, *93*. https://doi.org/10.1016/j.trd.2021.102770

Mouratidis, K. (2018). Is compact city livable? the impact of compact versus sprawled neighbourhoods on neighbourhood satisfaction [Publisher: SAGE Publications Ltd]. *Urban Studies*, *55*(11), 2408–2430. https://doi.org/10.1177/0042098017729109

Mouratidis, K. (2019). Compact city, urban sprawl, and subjective well-being. *Cities*, *92*, 261–272. https://doi.org/10.1016/j.cities.2019.04.013

Mouratidis, K. (2022). COVID-19 and the compact city: Implications for well-being and sustainable urban planning. *Science of The Total Environment*, *811*, 152332. https://doi.org/10.1016/j.scitotenv.2021.152332

Mouratidis, K., & Yiannakou, A. (2022). COVID-19 and urban planning: Built environment, health, and well-being in greek cities before and during the pandemic. *Cities*, *121*, 103491. https://doi.org/10.1016/j.cities.2021.103491

Mughal, M. O., Li, X.-X., & Norford, L. K. (2020). Urban heat island mitigation in singapore: Evaluation using WRF/multilayer urban canopy model and local climate zones. *Urban Climate*, *34*, 100714. https://doi.org/10.1016/j.uclim.2020.100714

Mulder, P., Dalla Longa, F., & Straver, K. (2023). Energy poverty in the netherlands at the national and local level: A multi-dimensional spatial analysis. *Energy Research & Social Science*, *96*, 102892. https://doi.org/10.1016/j.erss.2022.102892

Muñiz, I., & Dominguez, A. (2020). The impact of urban form and spatial structure on per capita carbon footprint in u.s. larger metropolitan areas. *Sustainability (Switzerland)*, *12*(1), 1–19. https://doi.org/10.3390/su12010389

Muñiz, I., & Rojas, C. (2019). Urban form and spatial structure as determinants of per capita greenhouse gas emissions considering possible endogeneity and compensation behaviors. *Environmental Impact Assessment Review*, *76*, 79–87. https://doi.org/10.1016/j.eiar.2019.02.002

Næss, P. (2014). Urban form, sustainability and health: The case of greater oslo [Publisher: Routledge _eprint: https://doi.org/10.1080/09654313.2013.797383]. *European Planning Studies*, *22*(7), 1524–1543. https://doi.org/10.1080/09654313.2013.797383

Nagel, J. (2015, September 25). *Gender and climate change: Impacts, science, policy* [Google-Books-ID: yT9PEAAAQBAJ]. Routledge.

Netherlands Enterprise Agency (RVO). (2023). *Cijfers elektrisch vervoer* [RVO.nl]. Retrieved November 8, 2023, from https://www.rvo.nl/onderwerpen/elektrisch-rijden/cijfers

Neuman, M. (2005). The compact city fallacy. *Journal of Planning Education and Research*, *25*(1), 11–26. https://doi.org/10.1177/0739456X04270466

Neumayer, E., & Plümper, T. (2007). The gendered nature of natural disasters: The impact of catastrophic events on the gender gap in life expectancy, 1981–2002 [Publisher: Routledge _eprint: https://doi.org/10.1111/j.1467-8306.2007.00563.x]. *Annals of the Association of American Geographers*, *97*(3), 551–566. https://doi.org/10.1111/j.1467-8306.2007.00563.x

Nijhuis, S. (2020). The noordoostpolder: A landscape planning perspective on the preservation and development of twentieth-century polder landscapes in the netherlands. In C. Hein (Ed.), *Adaptive strategies for water heritage: Past, present and future* (pp. 212–229). Springer International Publishing. https://doi.org/10.1007/978-3-030-00268-8_11

Nilsson, I., & Delmelle, E. (2018). Transit investments and neighborhood change: On the likelihood of change. *Journal of Transport Geography*, *66*, 167–179. https://doi.org/10.1016/j.jtrangeo.2017.12.001

Oakil, A. T. M., Nijland, L., & Dijst, M. (2016). Rush hour commuting in the netherlands: Gender-specific household activities and personal attitudes towards responsibility sharing. *Travel Behaviour and Society*, *4*, 79–87. https://doi.org/10.1016/j.tbs.2015.10.003

O'Brien, K., Eriksen, S., Sygna, L., & Naess, L. (2006). Questioning complacency: Climate change impacts, vulnerability, and adaptation in norway. *Ambio*, *35*(2), 50–56. https://doi.org/10.1579/0044-7447(2006)35[50:QCCCIV]2.0.CO;2

Oliveira, A., Lopes, A., Correia, E., Niza, S., & Soares, A. (2021). An urban climate-based empirical model to predict present and future patterns of the urban thermal signal. *Science of the Total Environment*, *790*. https://doi.org/10.1016/j.scitotenv.2021.147710

Oliveira, N. C. d., Albuquerque, J. F., Silva, M. W. N., Dalmas, F. B., & Portes, L. A. (2022). Green areas as promoters of health, leisure and physical activity: A systematic review [Number: 2]. *Revista de Gestão Ambiental e Sustentabilidade*, *11*(2), e22938–e22938. https://doi.org/10.5585/geas.v11i2.22938

Onderzoek en Statistiek Amsterdam. (2023). *Dataset: Woningvoorraad | Website Onderzoek en Statistiek*. Retrieved September 25, 2023, from https://onderzoek.amsterdam.nl/dataset/woningvoorraad

Osayemwenre, G., & Osibote, O. (2021). A review of health hazards associated with rainwater harvested from green, conventional and photovoltaic rooftops. *International Journal of Environmental Science and Development*, *12*(10), 289–303. https://doi.org/10.18178/IJESD.2021.12.10.1353

Osborne, N. (2015). Intersectionality and kyriarchy: A framework for approaching power and social justice in planning and climate change adaptation [Publisher: SAGE Publications]. *Planning Theory*, *14*(2), 130–151. https://doi.org/10.1177/1473095213516443

Palusci, O., Monti, P., Cecere, C., Montazeri, H., & Blocken, B. (2022). Impact of morphological parameters on urban ventilation in compact cities: The case of the tuscolano-don bosco district in rome. *Science of The Total Environment*, *807*, 150490. https://doi.org/10.1016/j.scitotenv.2021.150490

Parsons, K. (2019, February 5). *Human heat stress* [Google-Books-ID: COiIDwAAQBAJ]. CRC Press.

Perera, A. T. D., Javanroodi, K., Mauree, D., Nik, V. M., Florio, P., Hong, T., & Chen, D. (2023). Challenges resulting from urban density and climate change for the EU energy transition [Number: 4 Publisher: Nature Publishing Group]. *Nature Energy*, *8*(4), 397–412. https://doi.org/10.1038/s41560-023-01232-9

Phelan, P. E., Kaloush, K., Miner, M., Golden, J., Phelan, B., Silva, H., & Taylor, R. A. (2015). Urban heat island: Mechanisms, implications, and possible remedies [_eprint: https://doi.org/10.1146/annurev-environ-102014-021155]. *Annual Review of Environment and Resources*, *40*(1), 285–307. https://doi.org/10.1146/annurev-environ-102014-021155

Pichler, P.-P., Zwickel, T., Chavez, A., Kretschmer, T., Seddon, J., & Weisz, H. (2017). Reducing urban greenhouse gas footprints [Number: 1 Publisher: Nature Publishing Group]. *Scientific Reports*, *7*(1), 14659. https://doi.org/10.1038/s41598-017-15303-x

Pierer, C., & Creutzig, F. (2019). Star-shaped cities alleviate trade-off between climate change mitigation and adaptation [Publisher: IOP Publishing]. *Environmental Research Letters*, *14*(8), 085011. https://doi.org/10.1088/1748-9326/ab2081

Piquero, A. R., Riddell, J. R., Bishopp, S. A., Narvey, C., Reid, J. A., & Piquero, N. L. (2020). Staying home, staying safe? a short-term analysis of COVID-19 on dallas domestic violence. *American Journal of Criminal Justice*, *45*(4), 601–635. https://doi.org/10.1007/s12103-020-09531-7

Porrazzo, A., Samson, C., & Freudendal-Pedersen, M. (2022). Gender and mobility planning: The influence of national culture on planning processes. *Case Studies on Transport Policy*, *10*(2), 1102–1109. https://doi.org/10.1016/j.cstp.2022.03.020

Pörtner, H. O., Roberts, D. C., Adams, H., & Adelakan, I. (2022). Technical summary. In *Climate change 2022: Impacts, adaptation, and vulnerability. contribution of working group II to the sixth assessment report of the intergovernmental panel on climate change* (pp. 37–118). Cambridge University Press. doi:10.1017/9781009325844.002

Pramanik, S., Punia, M., Yu, H., & Chakraborty, S. (2022). Is dense or sprawl growth more prone to heat-related health risks? spatial regression-based study in delhi, india. *Sustainable Cities and Society*, *81*, 103808. https://doi.org/10.1016/j.scs.2022.103808

Primc, K., & Slabe-Erker, R. (2020). Social policy or energy policy? time to reconsider energy poverty policies. *Energy for Sustainable Development*, *55*, 32–36. https://doi.org/10.1016/j.esd.2020.01.001

(PvdA) Moorman, M., (GroenLinks) Groot Wassink, R., & (D66) van Dantzig, R. (2022, May). Amsterdams coalitieakkord 2022-2026. https://assets.amsterdam.nl/publish/pages/1012403/amsterdams_akkoord_250622.pdf

Ramaswami, A., Tong, K., Canadell, J. G., Jackson, R. B., Stokes, E. (, Dhakal, S., Finch, M., Jittrapirom, P., Singh, N., Yamagata, Y., Yewdall, E., Yona, L., & Seto, K. C. (2021). Carbon analytics for net-zero emissions sustainable cities [Number: 6 Publisher: Nature Publishing Group]. *Nature Sustainability*, *4*(6), 460–463. https://doi.org/10.1038/s41893-021-00715-5

Raworth, K. (2017). *Doughnut economics: Seven ways to think like a 21st-century economist* [Google-Books-ID: 7A4lDgAAQBAJ]. Chelsea Green Publishing.

Ren, C., Spit, T., Lenzholzer, S., Yim, H., van Hove, B., Chen, L., Kupski, S., Burghardt, R., & Katzschner, L. (2012). Urban Climate Map System for Dutch spatial planning. *International Journal of Applied Earth Observation and Geoinformation*, *18*(1), 207–221. https://doi.org/10.1016/j.jag.2012.01.026

Resch, E., Bohne, R., Kvamsdal, T., & Lohne, J. (2016). Impact of urban density and building height on energy use in cities. *96*, 800–814. https://doi.org/10.1016/j.egypro.2016.09.142

Reu Junqueira, J., Serrao-Neumann, S., & White, I. (2023). Developing and testing a cost-effectiveness analysis to prioritize green infrastructure alternatives for climate change adaptation. *Water and Environment Journal*, *37*(2), 242–255. https://doi.org/10.1111/wej.12832

Ricart, S., Berizzi, C., Saurí, D., & Terlicher, G. (2022). The social, political, and environmental dimensions in designing urban public space from a water management perspective: Testing european experiences. *Land*, *11*(9). https://doi.org/10.3390/land11091575

Rinkinen, J., Shove, E., & Smits, M. (2021). Conceptualising urban density, energy demand and social practice [Number: 1 Publisher: Ubiquity Press], *2*(1), 79–91. https://doi.org/10.5334/bc.72

Rišová, K. (2021). Questioning gender stereotypes: A case study of adolescents walking activity space in a small central european city. *Journal of Transport Geography*, *91*, 102970. https://doi.org/10.1016/j.jtrangeo.2021.102970

Ritchie, H., Roser, M., & Rosado, P. (2022). Energy. *Our World in Data*. Retrieved November 8, 2023, from https://ourworldindata.org/energy/country/netherlands

Rocco, T. S., & Plakhotnik, M. S. (2009). Literature reviews, conceptual frameworks, and theoretical frameworks: Terms, functions, and distinctions [Publisher: SAGE Publications]. *Human Resource Development Review*, *8*(1), 120–130. https://doi.org/10.1177/1534484309332617

Roche, L., Arendt, R., Bach, V., & Finkbeiner, M. (2023). The social impacts of resource extraction for the clean energy transition: A qualitative news media analysis. *Extractive Industries and Society*, *13*. https://doi.org/10.1016/j.exis.2023.101213

Rockström, J., Gupta, J., Qin, D., Lade, S. J., Abrams, J. F., Andersen, L. S., Armstrong McKay, D. I., Bai, X., Bala, G., Bunn, S. E., Ciobanu, D., DeClerck, F., Ebi, K., Gifford, L., Gordon, C., Hasan, S., Kanie, N., Lenton, T. M., Loriani, S., . . . Zhang, X. (2023). Safe and just earth system boundaries [Publisher: Nature Publishing Group]. *Nature*, 1–10. https://doi.org/10.1038/s41586-023-06083-8

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F. S., Lambin, E. F., Lenton, T. M., Scheffer, M., Folke, C., Schellnhuber, H. J., Nykvist, B., de Wit, C. A., Hughes, T., van der Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P. K., Costanza, R., Svedin, U., . . . Foley, J. A. (2009). A safe operating space for humanity [Number: 7263 Publisher: Nature Publishing Group]. *Nature*, *461*(7263), 472–475. https://doi.org/10.1038/461472a

Rosenberger, L., Leandro, J., Pauleit, S., & Erlwein, S. (2021). Sustainable stormwater management under the impact of climate change and urban densification. *Journal of Hydrology*, *596*, 126137. https://doi.org/10.1016/j.jhydrol.2021.126137

Ruimte en Duurzamheid Amsterdam. (2017). *Tussenrapportage Ruimte voor de Stad* [openresearch.amsterdam]. Retrieved September 25, 2023, from https://openresearch.amsterdam/nl/page/61921/tussenrapportage-ruimte-voor-de-stad

Rutherford, J., & Coutard, O. (2014). Urban energy transitions: Places, processes and politics of socio-technical change. *Urban Studies*, *51*(7), 1353–1377. https://doi.org/10.1177/0042098013500090

Ryder, S. S. (2017). A bridge to challenging environmental inequality: Intersectionality, environmental justice, and disaster vulnerability [Publisher: Social Thought and Research]. *Social Thought & Research*, *34*, 85–115. Retrieved June 1, 2023, from https://www.jstor.org/stable/44807699

Salonen, T., Hollands, J., Sesto, E., & Korjenic, A. (2022). Thermal Effects of Vertical Greening in Summer: An Investigation on Evapotranspiration and Shading of Façade Greening in Vienna. *Buildings*, *12*(10). https://doi.org/10.3390/buildings12101705

Salvati, A., & Coch, H. (2021). Urban climate and building energy performance in compact cities in mediterranean climate. In *Urban microclimate modelling for comfort and energy studies* (pp. 105–135). https://doi.org/10.1007/978-3-030-65421-4_6

Scheiner, J. (2016). School trips in germany: Gendered escorting practices. *Transportation Research Part A: Policy and Practice*, *94*, 76–92. https://doi.org/10.1016/j.tra.2016.09.008

Schmidt, C. (2004, May 25). The analysis of semi-structured interviews. In *A companion to qualitative research*. SAGE.

Schüle, S., Hilz, L., Dreger, S., & Bolte, G. (2019). Social inequalities in environmental resources of green and blue spaces: A review of evidence in the WHO european region. *International Journal of Environmental Research and Public Health*, *16*(7). https://doi.org/10.3390/ijerph16071216

Segura, R., Krayenhoff, E., Martilli, A., Badia, A., Estruch, C., Ventura, S., & Villalba, G. (2022). How do street trees affect urban temperatures and radiation exchange? observations and numerical evaluation in a highly compact city. *Urban Climate*, *46*. https://doi.org/10.1016/j.uclim.2022.101288

Seyedashraf, O., Bottacin-Busolin, A., & Harou, J. (2022). A design framework for considering spatial equity in sustainable urban drainage infrastructure. *Sustainable Cities and Society*, *85*. https://doi.org/10.1016/j.scs.2022.103960

Skougaard Kaspersen, P., Høegh Ravn, N., Arnbjerg-Nielsen, K., Madsen, H., & Drews, M. (2017). Comparison of the impacts of urban development and climate change on exposing European cities to pluvial flooding. *Hydrology and Earth System Sciences*, *21*(8), 4131–4147. https://doi.org/10.5194/hess-21-4131-2017

Slootweg, R., Vanclay, F., & van Schooten, M. (2001). Function evaluation as a framework for the integration of social and environmental impact assessment [Publisher: Taylor & Francis _eprint: https://doi.org/10.3152/147154601781767186]. *Impact Assessment and Project Appraisal*, *19*(1), 19–28. https://doi.org/10.3152/147154601781767186

Smith, P., Calvin, K., Nkem, J., Campbell, D., Cherubini, F., Grassi, G., Korotkov, V., Le Hoang, A., Lwasa, S., McElwee, P., Nkonya, E., Saigusa, N., Soussana, J.-F., Taboada, M. A., Manning, F. C., Nampanzira, D., Arias-Navarro, C., Vizzarri, M., House, J., . . . Arneth, A. (2020). Which practices co-deliver food security, climate change mitigation and adaptation, and combat land degradation and desertification? [_eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/gcb.14878]. *Global Change Biology*, *26*(3), 1532–1575. https://doi.org/10.1111/gcb.14878

Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of Business Research*, *104*, 333–339. https://doi.org/10.1016/j.jbusres.2019.07.039

Solitare, L. (2005). Prerequisite conditions for meaningful participation in brownfields redevelopment [Publisher: Routledge _eprint: https://doi.org/10.1080/09640560500294475]. *Journal of Environmental Planning and Management*, *48*(6), 917–935. https://doi.org/10.1080/09640560500294475

Solomon, G. M., Morello-Frosch, R., Zeise, L., & Faust, J. B. (2016). Cumulative environmental impacts: Science and policy to protect communities. *Annual Review of Public Health*, *37*, 83–96. https://doi.org/10.1146/annurev-publhealth-032315-021807

Stark, J., & Meschik, M. (2018). Women's everyday mobility: Frightening situations and their impacts on travel behaviour. *Transportation Research Part F: Traffic Psychology and Behaviour*, *54*, 311–323. https://doi.org/10.1016/j.trf.2018.02.017

Steffen, W., Richardson, K., Rockström, J., Cornell, S. E., Fetzer, I., Bennett, E. M., Biggs, R., Carpenter, S. R., de Vries, W., de Wit, C. A., Folke, C., Gerten, D., Heinke, J., Mace, G. M., Persson, L. M., Ramanathan, V., Reyers, B., & Sörlin, S. (2015). Planetary boundaries: Guiding human development on a changing planet [Publisher: American Association for the Advancement of Science]. *Science*, *347*(6223), 1259855. https://doi.org/10.1126/science.1259855

Stone, B., Hess, J. J., & Frumkin, H. (2010). Urban Form and Extreme Heat Events: Are Sprawling Cities More Vulnerable to Climate Change Than Compact Cities? [Publisher: Environmental Health Perspectives]. *Environmental Health Perspectives*, *118*(10), 1425–1428. https://doi.org/10.1289/ehp.0901879

Sun, Z., Zhang, F., Wang, Y., & Shao, Z. (2023). Literature review and analysis of the social impact of a just energy transition. *Frontiers in Sustainable Food Systems*, *7*. https://doi.org/10.3389/fsufs.2023.1119877

Swilling, M. (2016). The curse of urban sprawl: How cities grow, and why this has to change. *The Guardian*. Retrieved September 2, 2023, from https://www.theguardian.com/cities/2016/jul/12/urban-sprawl-how-cities-grow-change-sustainability-urban-age

Tan, X., Gan, T. Y., & Horton, D. E. (2018). Projected timing of perceivable changes in climate extremes for terrestrial and marine ecosystems [_eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/gcb.14329]. *Global Change Biology*, *24*(10), 4696–4708. https://doi.org/10.1111/gcb.14329

Tapia, C., Abajo, B., Feliu, E., Mendizabal, M., Martinez, J. A., Fernández, J. G., Laburu, T., & Lejarazu, A. (2017). Profiling urban vulnerabilities to climate change: An indicator-based vulnerability assessment for european cities. *Ecological Indicators*, *78*, 142–155. https://doi.org/10.1016/j.ecolind.2017.02.040

Teotónio, I., Silva, C. M., & Cruz, C. O. (2018). Eco-solutions for urban environments regeneration: The economic value of green roofs. *Journal of Cleaner Production*, *199*, 121–135. https://doi.org/10.1016/j.jclepro.2018.07.084

Teotónio, I., Silva, C. M., & Cruz, C. O. (2021). Economics of green roofs and green walls: A literature review. *Sustainable Cities and Society*, *69*, 102781. https://doi.org/10.1016/j.scs.2021.102781

The World Bank. (2023a). *7th urbanization and poverty reduction research conference* [Who we are]. Retrieved September 2, 2023, from https://www.worldbank.org/en/events/2023/01/30/7th-urbanization-and-poverty-reduction-research-conference

The World Bank. (2023b). *Urban development - overview* [World bank]. Retrieved September 2, 2023, from https://www.worldbank.org/en/topic/urbandevelopment/overview

Thomas, P., Swaminathan, A., & Lucas, R. M. (2012). Climate change and health with an emphasis on interactions with ultraviolet radiation: A review [_eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1365-2486.2012.02706.x]. *Global Change Biology*, *18*(8), 2392–2405. https://doi.org/10.1111/j.1365-2486.2012.02706.x

Toboso-Chavero, S., Madrid-López, C., Durany, X., & Villalba, G. (2021). Incorporating user preferences in rooftop food-energy-water production through integrated sustainability assessment*. *Environmental Research Communications*, *3*(6). https://doi.org/10.1088/2515-7620/abffa5

Torraco, R. J. (2005). Writing integrative literature reviews: Guidelines and examples [Publisher: SAGE Publications]. *Human Resource Development Review*, *4*(3), 356–367. https://doi.org/10.1177/1534484305278283

Torraco, R. J. (2016). Writing integrative literature reviews: Using the past and present to explore the future. *Human Resource Development Review*, *15*(4), 404–428. https://doi.org/10.1177/1534484316671606

Toselli, S., Bragonzoni, L., Dallolio, L., Grigoletto, A., Masini, A., Marini, S., Barone, G., Pinelli, E., Zinno, R., Mauro, M., Astorino, G., Loro Pilone, P., Galli, S., & Maietta Latessa, P. (2022). The effects of park based interventions on health: The italian project "moving parks" [Number: 4 Publisher: Multidisciplinary Digital Publishing Institute]. *International Journal of Environmental Research and Public Health*, *19*(4), 2130. https://doi.org/10.3390/ijerph19042130

TU Delft. (2023). *Human Research Ethics* [TU Delft]. Retrieved June 21, 2023, from https://www.tudelft.nl/over-tu-delft/strategie/integriteitsbeleid/human-research-ethics

UN DESA | United Nations Department of Economic and Social Affairs. (2018). *68% of the world population projected to live in urban areas by 2050, says UN*. Retrieved September 2, 2023, from https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html

UN DESA | United Nations Department of Economic and Social Affairs. (2023). *Goal 13*. Retrieved October 22, 2023, from https://sdgs.un.org/goals/goal13

UNFCC, U. N. F. o. C. C. (2021). *Energy - climate action pathway | UNFCCC*. Retrieved October 10, 2023, from https://unfccc.int/climate-action/marrakech-partnership/reporting-tracking/pathways/energy-climate-action-pathway#Climate-Action-Pathway-2021

Van Ryswyk, K., Prince, N., Ahmed, M., Brisson, E., Miller, J. D., & Villeneuve, P. J. (2019). Does urban vegetation reduce temperature and air pollution concentrations? findings from an environmental monitoring study of the central experimental farm in ottawa, canada. *Atmospheric Environment*, *218*, 116886. https://doi.org/10.1016/j.atmosenv.2019.116886

Vanclay, F. (2002). Conceptualising social impacts. *Environmental Impact Assessment Review*, *22*(3), 183–211. https://doi.org/10.1016/S0195-9255(01)00105-6

van Dort, A., Vos, M., & Bos, M. (2023, July 13). *Meedenken over Ontwikkelstrategie 2035 - Verslag van het gesprek met de stad over de buurten van de toekomst* [openresearch.amsterdam]. Retrieved September 30, 2023, from https://openresearch.amsterdam/nl/page/98703/in-gesprek-met-de-stad-over-de-buurten-van-de-toekomst

Vanos, J. K., Baldwin, J. W., Jay, O., & Ebi, K. L. (2020). Simplicity lacks robustness when projecting heat-health outcomes in a changing climate [Number: 1 Publisher: Nature Publishing Group]. *Nature Communications*, *11*(1), 6079. https://doi.org/10.1038/s41467-020-19994-1

Ven, G. v. d. (P., NIMICI (Apeldoorn), & International Commission on Irrigation and Drainage. (2004). *Man-made lowlands: History of water management and land reclamation in the netherlands* (4th rev. ed) [Section: 432 p. : illustrations ; 29 cm]. Matrijs.

Venter, Z. S., Figari, H., Krange, O., & Gundersen, V. (2023). Environmental justice in a very green city: Spatial inequality in exposure to urban nature, air pollution and heat in oslo, norway. *Science of The Total Environment*, *858*, 160193. https://doi.org/10.1016/j.scitotenv.2022.160193

Versey, H. S. (2021). Missing pieces in the discussion on climate change and risk: Intersectionality and compounded vulnerability [Publisher: SAGE Publications]. *Policy Insights from the Behavioral and Brain Sciences*, *8*(1), 67–75. https://doi.org/10.1177/2372732220982628

Vich, G., Marquet, O., & Miralles-Guasch, C. (2019). Green streetscape and walking: Exploring active mobility patterns in dense and compact cities. *Journal of Transport & Health*, *12*, 50–59. https://doi.org/10.1016/j.jth.2018.11.003

Villanueva, K., Badland, H., Kvalsvig, A., O'Connor, M., Christian, H., Woolcock, G., Giles-Corti, B., & Goldfeld, S. (2016). Can the neighborhood built environment make a difference in children's development? building the research agenda to create evidence for place-based children's policy. *Academic Pediatrics*, *16*(1), 10–19. https://doi.org/10.1016/j.acap.2015.09.006

Wang, P., Liu, Z., & Zhang, L. (2021). Sustainability of compact cities: A review of inter-building effect on building energy and solar energy use. *Sustainable Cities and Society*, *72*, 103035. https://doi.org/10.1016/j.scs.2021.103035

Wang, R., Feng, Z., Pearce, J., Yao, Y., Li, X., & Liu, Y. (2021). The distribution of greenspace quantity and quality and their association with neighbourhood socioeconomic conditions in guangzhou, china: A new approach using deep learning method and street view images. *Sustainable Cities and Society*, *66*, 102664. https://doi.org/10.1016/j.scs.2020.102664

Wang, Z., Ettema, D., & Helbich, M. (2023). Age as effect modifier of the associations between the physical environment and adults' neighborhood walking in the netherlands. *Cities*, *135*. https://doi.org/10.1016/j.cities.2023.104194

Wargocki, P. (2013). The effects of ventilation in homes on health [Publisher: Taylor & Francis]. *International Journal of Ventilation*, *12*(2), 101–118.

Webster, J., & Watson, R. T. (2002). Analyzing the past to prepare for the future: Writing a literature review [Publisher: Management Information Systems Research Center, University of Minnesota]. *MIS Quarterly*, *26*(2), xiii–xxiii. Retrieved July 24, 2023, from https://www.jstor.org/stable/4132319

Westerink, J., Haase, D., Bauer, A., Ravetz, J., Jarrige, F., & Aalbers, C. B. M. (2013). Dealing with sustainability trade-offs of the compact city in peri-urban planning across european city regions [Publisher: Routledge _eprint: https://doi.org/10.1080/09654313.2012.722927]. *European Planning Studies*, *21*(4), 473–497. https://doi.org/10.1080/09654313.2012.722927

Whittemore, R., & Knafl, K. (2005). The integrative review: Updated methodology [_eprint: https://onlinelibrary.wiley.com 2648.2005.03621.x]. *Journal of Advanced Nursing*, *52*(5), 546–553. https://doi.org/10.1111/j.1365-2648.2005.03621.x

Williams, P. C., Binet, A., Alhasan, D. M., Riley, N. M., & Jackson, C. L. (2023). Urban planning for health equity must employ an intersectionality framework [Publisher: Routledge _eprint: https://doi.org/10.1080/01944363.2022.2079550]. *Journal of the American Planning Association*, *89*(2), 167–174. https://doi.org/10.1080/01944363.2022.2079550

Wong, K. V., Paddon, A., & Jimenez, A. (2012). Heat island effect aggravates mortality, 271–285. https://doi.org/10.1115/IMECE2011-62785

Wright, J., Lytle, J., Santillo, D., Marcos, L., & Mai, K. (2021). Addressing the water–energy–food nexus through enhanced green roof performance. *Sustainability (Switzerland)*, *13*(4), 1–13. https://doi.org/10.3390/su13041972

Xiao, Y., & Watson, M. (2019). Guidance on conducting a systematic literature review. *Journal of Planning Education and Research*, *39*(1), 93–112. https://doi.org/10.1177/0739456X17723971

Xie, L., Hu, X., Zhang, X., & Zhang, X.-B. (2022). Who suffers from energy poverty in household energy transition? evidence from clean heating program in rural china. *Energy Economics*, *106*, 105795. https://doi.org/10.1016/j.eneco.2021.105795

Xiong, H. (2019). The construction of women's social spaces through physical exercise in urban china [Publisher: Routledge _eprint: https://doi.org/10.1080/17430437.2019.1614919]. *Sport in Society*, *22*(8), 1415–1432. https://doi.org/10.1080/17430437.2019.1614919

Yang, L., van Dam, K. H., Majumdar, A., Anvari, B., Ochieng, W. Y., & Zhang, L. (2019). Integrated design of transport infrastructure and public spaces considering human behavior: A review of state-of-the-art methods and tools. *Frontiers of Architectural Research*, *8*(4), 429–453. https://doi.org/10.1016/j.foar.2019.08.003

Yıldız, S., Kıvrak, S., Gültekin, A. B., & Arslan, G. (2020). Built environment design - social sustainability relation in urban renewal. *Sustainable Cities and Society*, *60*, 102173. https://doi.org/10.1016/j.scs.2020.102173

Yola, L., Siong, H. C., & Djaja, K. K. (2021). Impact of urban configurations on airflow: Tropical context study. In S. S. Emamian, T. O. Adekunle, U. Nangkula, & M. Awang (Eds.), *ICSDEMS 2019* (pp. 281–288). Springer. https://doi.org/10.1007/978-981-15-3765-3_29

Zaffagnini, T., Lelli, G., Fabbri, I., & Negri, M. (2022). Innovative street furniture supporting electric micro-mobility for active aging. In S. Scataglini, S. Imbesi, & G. Marques (Eds.), *Internet of* *things for human-centered design: Application to elderly healthcare* (pp. 313–327). Springer Nature. https://doi.org/10.1007/978-981-16-8488-3_15

Zang, P., Qiu, H., Zhang, H., Chen, K., Xian, F., Mi, J., Guo, H., Qiu, Y., & Liao, K. (2023). The built environment's nonlinear effects on the elderly's propensity to walk. *Frontiers in Ecology and Evolution*, *11*. https://doi.org/10.3389/fevo.2023.1103140

Zhang, Y. (2013). Urban metabolism: A review of research methodologies. *Environmental Pollution*, *178*, 463–473. https://doi.org/10.1016/j.envpol.2013.03.052

Zhang, Z., Sato, Y., Dai, J., Chui, H., Daigger, G., Van Loosdrecht, M., & Chen, G. (2023). Flushing toilets and cooling spaces with seawater improve water-energy securities and achieve carbon mitigations in coastal cities. *Environmental Science and Technology*, *57*(12), 5068–5078. https://doi.org/10.1021/acs.est.2c07352

Appendix A

Conceptualisation

A.1. Vanclay's SIs and individual social impacts

Table A.1: The social impact categories (SI) and individual social impacts of Vanclay (2002) applied in this project.

SI	Components	SI	components
Health	actual health	**livability**	perception of crime and safety
	health of family, personal loss of a family member		perceived quality of the BE
	well-being, mental health		actual quality of the BE
	perceived health		disruption of daily living practices
	nutrition		leisure and recreation
	positive/negative feelings leading to interest groups		aesthetic quality of the BE
	uncertainty		environmental amenity value
	aspirations for the future		physical quality of housing
	experience of stigmatisation		homeliness, social quality of housing
	annoyance, dissatisfaction, experience of outrage		availability of housing facilities
	autonomy		adequacy of social infrastructure
			actual crime and safety

Table A.1 continued from previous page

SI	Components	SI	components
SI	**components**	**SI**	**component**
economic impacts	workload	**indicative cultural impacts**	change in cultural values
	standard of living/affluence		cultural affrontage
	access to public goods/services		cultural integrity
	access to government/social services		cultural marginalisation
	economic prospertiy/resilience		profanisation of culture
	income		loss local language or dialect
	property values		loss natural/cultural heritage
	occupational status		
	level of unemployment in the community		
	loss of employment options		
	replacement costs of environmental functions		
	economic dependency of vulnerability		
	disruption of local economy		
	burden of national debt		
SI	**component**	**SI**	**component**
family and community impacts	alterations of family structures	**institutional, legal, political and equity impacts**	workload and viability of government or formal agencies
	change of sexual relations		workload and viability of non-government agencies and informal agencies including community organisations
	obligations to living elders		integrity of government and government agencies
	family violence		loss of tenure or legal rights
	disruption of social networks		loss of subsidiarity

Table A.1 continued from previous page

SI	Components	SI	components
	changed demographic structure of the community		violation of human rights
	community identification and connection		participation in decision-making
	perceived and actual community cohesion		access to legal procedures and to legal advice
	social differentiation and inequity		impact equity (notions about fairness in the distribution of impacts across the community
	social tension and violence		
SI	**components**		
gender relations	women's physical integrity		
	personal autonomy of women		
	gendered division of production-oriented labour		
	gendered division of household labour		
	gendered division of reproductive labour		
	gender-based control over, and access to, resources and services		
	equity of educational achievement between girls and boys		
	political emancipation of women		

A.2. The densification elements of Saaty and Dantzig

Table A.2 shows the densification characteristics of Dantzig and Saty, 1973 in Bibri et al. (2020).

Table A.2: The densification characteristics of Dantzig and Saaty, 1973, as displayed in Bibri et al. (2020). Here, densification is made up from urban form features, spatial features and social functions.

Urban form features	**Spatial features**	**Social functions**
high density settlements	mixed land use	social fairness
less dependence on automobile	diversity of life	self-sufficiency of daily life
clear boundary from surrounding areas	clear identity	independence of government

A.3. The ET Conceptualisation

Table A.3 shows the elements and sectors of the ET that I include in my scope for this transition.

Table A.3: OLD Understanding of the ET applied in this thesis. Separation into sectors of energy and electricity use in the left columns and ET elements in the right column. The cells of the two columns are not displayed with association to each other, but meant to give an overview of my approach to the term and concept of ET. *ET sectors in (...) out of scope.

ET sectors *(...) out of scope	**ET elements**
mobility	urban electric and thermal energy generation (wind, solar, PV, thermal)
heating and cooling	urban energy and electricity storage
(production, manufacturing, waste)*	measures of use reduction and efficiency
amenities and services (food and feed)*	urban electricity and energy transport and charging infrastructure
(construction)*	urban energy and electricity innovation technologies

A.4. The CCA Conceptualisation

Table A.4 provides an overview of the CCA understanding applied in this thesis.

Table A.4: Understanding of the CCA applied in this thesis. Separation into sectors in which CCA is conducted in the left column and CCA elements in the right column. The cells of the two columns are not displayed with association to each other, but meant to give an overview of my approach to the term and concept of CCA. Based on the conceptualisation of C40 Cities (https://www.c40.org/what-we-do/scaling-up-climate-action/adaptation-water/). The element of thermal comfort includes the Urban Heat Island effect (UHIE, indoor and outdoor temperatures. These are certainly related to each other. The distinction was nonetheless made to distinguish between studies only considering individual aspects of urban temperature.

CCA sector	**CCA elements**
management	extreme events early warning system
thermal comfort	cooling surfaces
fluvial/marine floods	river catchment (management)
pluvial floods	nature-based barriers
drought/freshwater/potable water	freshwater use (system) efficiency
-	extreme events emergency response plan
	tree cover and vegetation
	(sustainable) drainage systems
	artificial barriers

Table A.4: Understanding of the CCA applied in this thesis. Separation into sectors in which CCA is conducted in the left column and CCA elements in the right column. The cells of the two columns are not displayed with association to each other, but meant to give an overview of my approach to the term and concept of CCA. Based on the conceptualisation of C40 Cities (https://www.c40.org/what-we-do/scaling-up-climate-action/adaptation-water/). The element of thermal comfort includes the Urban Heat Island effect (UHIE, indoor and outdoor temperatures. These are certainly related to each other. The distinction was nonetheless made to distinguish between studies only considering individual aspects of urban temperature.

CCA sector	CCA elements
	treatment, recycling/re-use improvements
	social infrastructure and education
	evapotranspiration

A.5. Social impact conceptualisation literature

This section includes the background literature of chapter 3. Each subsection aligns with one of the SI's of Vanclay. This literature is the base for figure 3.1.

A.5.1. Health impacts

Actual health and mental well-being, nutrition, the perception of health - which in turn also affects mental well-being - life uncertainty, dissatisfaction of engagement in interest groups are counted to the health SI in the same way as an individual's autonomy, aspirations for the future or experience of stigmatisation. Reviewing literature on the influence of a densified urban environment on human health interlinks to a large extent with the other SI. The inter-connectivity of SI's and how social determinants contribute to human health was subject to the work of Jennings et al. (2016). This emphasises the need for urban planning policies that are aware of intersectionality and systemic approaches.

Urban form influences human health and well-being, including physical and mental health (Nieuwenhuijsen, 2021; Kim and Yoo, 2019). Factors such as infrastructure, green spaces, neighborhood facilities, and street environments contribute to physical health by promoting physical activity (Janeczko et al., 2020; Kim and Yoo, 2019; Oliveira et al., 2022; Rissel et al., 2012). However, increased pedestrian activity can also lead to pedestrian-vehicle collisions and accidents (Miranda-Moreno et al., 2011). The presence and use of green or blue spaces, along with physical activity, are generally associated with increased life satisfaction and well-being (Janeczko et al., 2020; Kim and Yoo, 2019; Kondo et al., 2018). Noise negatively impacts well-being (Forssén et al., 2022; Moebus et al., 2020). Walkable distances improve the autonomy and mobility of urban residents, particularly for elderly, children, low-income groups, and women (Akinci et al., 2022; Cinderby et al., 2018; Mitra et al., 2021; Salon and Gulyani, 2010). However, the autonomy and travel choices of disabled residents are highly dependent on public transport availability (Park et al., 2023). Walkable urban developments contribute to gender equality in out-of-home activities (Lo and Houston, 2018). Mobility levels also impact access to amenities and public services, indirectly affecting health (Jose et al., 2021; Salthammer and Morrison, 2022). Air pollution and noise can negatively affect comfort, physical health, and mental well-being (Frontczak and Wargocki, 2011; Guillerm and Cesari, 2015). Clean air is a human right, and its absence infringes on human rights (Guillerm and Cesari, 2015).

Considering the exceptional circumstances in the wake of the SarsCoV-2 pandemic, Mouratidis and Yiannakou (2022) discuss the complicated relationship of urban morphology and public health during the year 2020. Their literature review highlights, that while urban density and population proximity influence virus transmission, the importance of safe public or individual transport, urban green space for recreation, home unit size, access to facilities not only (directly, i.e. virus infection, or indirectly, e.g. physical exercise) impact the physical health, but also are determinants of mental stress (e.g. use of public transport perceived as dangerous) or well-being (creative outdoor social interaction in neighbourhood communities). As Mouratidis (2022) summarised, the pandemic indirectly impacted health and well-being through state measures, changed behaviour and emotional response. For instance, residents of denser neighbourhoods participating in their survey reported a larger decrease of happiness during COVID-19 in comparison to the participants sampled from less dense neighbourhoods. Similarly, residents living with higher access to transport reported an increase in anxiety to a larger extend than the participants living in neighbourhoods with a smaller accessibility to public transport (Mouratidis, 2022, p. 7).

A major consequence of urban morphology, and especially the densified urban form, is the emergence of the **Urban Heat Island Effect (UHIE)**. Heat accumulation during the day through solar radiation absorption, intra-surface reflection, less evapotranspiration due to sealed, non-vegetated surfaces and less fresh air corridors diminish diurnal and particularly nocturnal cooling. Especially pedestrians are affected by daytime UHIE (Jamei et al., 2016). Next to pedestrians' increased exposure to solar radiation, pavements and their materials may highly influence UHIE effects on pedestrians (Djekic et al., 2018) The physiological experience of the surroundings is defined as **human thermal comfort**. While cold or moderate climates may adopt higher temperatures and thermal comfort levels through the UHIE, adverse thermal comfort due to heat can lead to human heat stress. As a consequence, health, well-being and productivity may decline (Parsons, 2019). Not only air temperature, but radiant temperature, air velocity and humidity as well as clothing and the human metabolic rate/physical activity combined cause a person to experience heat stress. The latter two make up the human disposition, the first four the externally generated heat stress (Lundgren Kownacki et al., 2019; Parsons, 2019).
How a human reacts to the heat stress is highly dependent upon the individual's pre-existing vulnerability and adaptive capacity. Due to this, predictions on how heat stress affects productivity, health and well-being of a human are not linear (Vanos et al., 2020). For example, Antoniadis et al. (2020) discuss that schoolyard design may, even though adapted to an adult's thermal comfort, be detrimental to children's thermal comfort as temperature, humidity and ventilation sensation of children differs from a grown human.

On a large scale this complexity complicates reliable estimates of CC impacts. On an individual's scale, it can be assumed that excess heat diminishes human health, well-being and autonomy, especially in the choice of mobility mode, the perception of quality of the living environment and its recreational and leisure value, disrupts daily living practices to adapt to the heat, necessitates increased replacement costs of environmental functions. Moreover, in the urban context (and to the largest extent excluding conventional agricultural produce) second order impacts are created: decreased human productivity (Lan et al., 2010) and increased replacement costs for health and environmental functions decrease income as well as the standard of living.

Many intersectional factors can determine residents' vulnerability and adaptability to heat. Amongst these are the housing quality, such as indoor and outdoor shading, ventilation and insulation, the affordability and availability of water, cooling devices as well as the electricity for such devices, and knowledge of adaptation practices or the capacity to engage such practices (Maller & Strengers, 2011). These factors can contribute to an exacerbation of existing urban inequality, i.e. social differentiation and inequity. As Chakraborty et al. (2019) stated, there existed a correlation across 25 cities between lower income and higher UHIE exposure. Comparatively, Mehrotra et al. (2018) describe a statistically significant clustering of slum urban form and high land surface temperatures. Overall, these social disadvantages amount to the phenomenon of "thermal inequity" (for a discussion see Byrne et al. (2016), Mitchell and Chakraborty (2015), and Mitchell and Chakraborty (2014)). In the worst case, the UHIE can aggravate mortality (Wong et al., 2012).

Due to the UHIE, cities are facing double risks from a warming climate (Lemonsu et al., 2015). Increased temperatures also infer increased pollution levels indoors and outdoors (Jose et al., 2021). Groups with a lower level of capacity building for adaptive measures, such as lower access, availability or affordability of energy for cooling may experience a promulgated risk of heat (Maller & Strengers, 2011). This also interacts with the ET, as energy sources and grids shift. But not only the UHIE has been discussed as a link between CC and health. McGregor and Ren (2021) highlight that "[c]limate threats [...] [infer] a range of possible health impacts including death, physical injury, heat-related illness, vector- and water-borne disease and mental illness" (McGregor & Ren, 2021, p. 3). CA through the installation of solar PV panels was reported to created adverse health impacts. In their study on panel residuals and pollutants set free due to cracks, Osayemwenre and Osibote (2021) found that rainwater harvested on rooftops with PV installations for which these reduced quality features were the case, led to toxins in the collected water. This was in particular the case in low-income areas where quality and frequency of repair were lower.

The impact of densification on individual autonomy and the autonomy of women is strongly connected to the options of walkability and cyclability. Therefore, if the physical infrastructure quality facilitates safe walking and cycling, residents' autonomy and particularly the autonomy of women (Kabisch et al., 2016) are strengthened. Overall, the accessibility also increases for other groups of lower mobility, such as elderly or children (Cutts et al., 2009)
Several second order impacts arise from changed levels of autonomy. Employment opportunities might increase, stabilizing income and the standard of living. Health and well-being can be affected positively through increased physical and outdoor activities (Cutts et al., 2009). Social networks can be strengthened if social network points are accessible more easily. This might increase safety and further strengthen women's autonomy and access to resources and services.

A.5.2. Quality of the built environment - Livability impacts

How Vanclay (2002) establishes the SI livability is shown in Table A.1 in Appendix A.1: the actual and perceived, as well as the aesthetic quality of the built environment can be named as overlapping aspects. In terms of housing, the physical quality, social quality and availability are considered. Building on the social side of the urban fabric, the adequacy of social infrastructures, the disruption of daily living practices and environmental amenity value as well as leisure and recreation are observed in this category. Lastly, actual and perceived crime and safety are part of this group.

Urban morphology defines many components of urban climate and perceived or actual livability. Amongst these are temperature, lighting, walkways, sense of security and many more. How facades, ground floors, roofs and heights of buildings are designed, occupied and maintained therefore has significant impact on the livability and perceived quality of the the built environment. Additionally, how a neighbourhood infrastructure is laid out, accessible and how buildings are oriented towards each other defines its livability. For instance, outdoor spaces become even more important in times of heat: Indoor temperatures can be up to 50 % higher than outdoor temperatures (Lundgren Kownacki et al., 2019). Street morphology and vertical obstruction of air flows were identified as beneficial for ventilation (Yola et al., 2021). Street canyons on the other hand increased air pollution levels (Hoshiko et al., 2012). The recreational value and necessity of outdoor physical infrastructure is even higher if the housing quality is poor and the residents' capacity to engage in cooling measures is low. As Van Ryswyk et al. (2019) pointed out, large green spaces in city centers positively affect temperature and pollution level reduction in areas adjacent to the space.

Actual housing quality may be determined by the residents' income group. Solomon et al. (2016) found that pre-dominantly low-income groups face cumulative exposures and poor housing quality, thereby re-confirming adverse health, well-being and income status. Likewise, Kolokotsa and Santamouris (2015) reviewed studies on the inter-dependency of income, indoor living quality in cold and heat seasons and energy consumption, health and indoor comfort. They concluded a correlation between these and household income and location. This conclusion contributes to the assumption of geo-spatial urban inequalities between socio-economic groups. They also find that low-cost heating created adverse environmental effects, while in the summer months residents of such housing units experiences discomfort and heat stress. In general, building envelopes, air and acoustic quality were lower in these cases. Also Wargocki (2013) found that low income neighbourhoods had stronger associations with dampness of the building envelope. In addition, indoor pollutant concentrations in for these housing units were higher as they were more frequently located close to industrial sites and traffic nodes. The association between low-income housing and contamination levels has already been made more than 20 years ago by Mielck and Heinrich (2002). Poor quality housing exacerbating social differentiation was also subject to the review of Howden-Chapman et al. (2023). They found that differentiation of indigenous groups, ethnic minorities and income groups was also reflected in housing quality, especially in the public housing sector.

In their spatial analysis of survey data, Mouratidis and Yiannakou (2022) found a negative association of neighbourhood density with life satisfaction. In the comparison between residents of dense and less dense areas, this negative association was larger for residents in dense neighbourhoods. Additionally, dense neighbourhoods lead to a large decline in leisure satisfaction of residents - the availability of green space buffering this decrease. Dwellings of a larger size showed a positive association with life satisfaction and residents' happiness and proximity to amenities showed a positive correlation with personal relationships satisfaction during the SarsCoV-2 pandemic (Mouratidis & Yiannakou, 2022, p. 5-7).

Also where leisure and recreation and physical and social quality are concerned, the existence or absence of green space is crucial. Green, public spaces embedded the physical urban fabric can have positive associations with social cohesion, and may pose to be nudging outdoor activity especially for disadvantaged groups wile decreasing the impacts of the UHIE and CC (Lauria, 2023). Urban green space (UGS), sometimes defined as urban green infrastructure (UGI, for instance Ignatieva and Mofrad (2023)), fulfills a central role in urban planning. If for socio-cultural, ecological or technological reasons (see nature-based solutions, NBS) (Babí Almenar et al., 2021; Ignatieva & Mofrad, 2023), the effect of green areas in cities has been recognised (see for instance Brindley et al. (2018) and Segura et al. (2022)). The landscape structures and use of land falling under this definition are plenty. In their observation of Canberra, Ignatieva and Mofrad (2023) established a typology comprised of 33 distinct UGS, making up for 10 forms of UGI. While such a taxonomy is evidently context-specific, their work can be seen as an example of the variety in UGS, UGI as well as their impacts.

In their influential 2007 elaboration, Fuller et al. (2007) showed that psychological benefits for urban human residents increase with the richness of species in UGS. However, the argument has also been raised that UGS and NBS need to be implemented and maintained with caution. Urban densification interventions ought to accommodate for sufficient urban green space as this generates higher quality physical infrastructures, leading to positive health, well-being and recreational influences (Cutts et al., 2009; Fuller et al., 2007; N. C. d. Oliveira et al., 2022). Parks as recreational space has been reported as contributing to the physical and mental well-being during the COVID-19 pandemic especially for women (Toselli et al., 2022). However, this might also emphasise undesired outcomes such as increase in pests or disease vectors. Also the risk of littering and vandalism need attention of accompanying policies (Al-mosa et al., 2017).

Ownership and access to UGS and their beneficial effects can be extremely disparate (Brindley et al., 2018). For the World Health Organisation's (WHO) European region, Schüle et al. (2019) pointed at the suggestion of lower green space availability in socio-economically deprived urban areas. Similarly, in their case study of Sheffield in the UK, Mears et al. (2019) showed that deprived areas showed an association with lower quality of green spaces and higher crowding in these areas. But, in parallel, in these areas favorable accessibility of green spaces existed, which underlines the important distinction between green space access, quantity and (perceived) social or environmental quality. In their Chinese case study, R. Wang et al. (2021) associated a neighbourhood's socio-economic status, and in particular changes in the socio-economic status, with green space quality. The quantity of green space in the study area was less susceptible to the neighbourhoods' socio-economic status.

Additionally, the perceived and actual safety in or accessibility to UGS for all population groups needs to be kept in mind at an early planning stage. In two case studies, Ditton et al. (1983) and Arnberger and Brandenburg (2007) reported that residents who perceived parks as overcrowded chose to re-locate to other green spaces for recreational value - if they had the resources to do so. The social value of public spaces may also be improved if CCA measures are undertaken (Foshag et al., 2020).

When flood risk prevention, biodiversity increase, UHIE mitigation, noise dimming and water quality and storm drainage were taken into account, the socio-environmental net present value of green roofs leads to a positive cost-benefit analysis result Teotónio et al. (2018). From a systems thinking approach, it is important to include the note of Bianchini and Hewage (2012), that the vast social cost share of green roofs arises during manufacturing and commissioning. Therefore, attention to these contributing factors needs to be paid during the design and construction of green roofs to keep monetary investments for interested owners and communities low but social payback high. The social quality and sense of community of residents has been described as independent from usage frequencies of public spaces and amenities. Rather, the perceived quality of these surroundings was positively associated with the social quality (Francis et al., 2012). In their review on green roofs and green walls, Teotónio et al. (2021), looked at quantitative and qualitative studies. In these works, even if financial performances in terms of costs and benefits are low, the social and ecological benefits were high. Air quality, aesthetics, noise dimming, recreational space

Livability of the built environment is experienced distinctly also between age groups. Children, spending a high share of time outside when not at home or at school perceive public space, differently than adults (Villanueva et al., 2016). Also the perception of safety differs amongst population groups. In the case of open and green spaces, Rišová (2021) assessed the walking activity space of adolescent binary gender groups and found that girls seemed to be active in a smaller radius than the boys' group. But not only did they move rather in higher proximity to the city center or adjacent streets, but also did they - in contrast to the male group - show an activity distinction between daytime and nighttime hours. This suggested a stronger feeling of safety during the day.

How and where a resident moves is also due to public space design and transportation networks. The quality of the physical and social infrastructure is crucial for resident mobility patterns and daily routines. Route choices, physical activity, crime perception and social interaction quality all may be subject to the design of public space (Yang et al., 2019). Walkability is often deemed a central goal of densification. Residents of all age groups react differently and move differently. Built environment features of walkability have to be seen in context and adjusted to the demographic needs in the population (Z. Wang et al., 2023; Zang et al., 2023). For instance, the inclusion of benches, fountains, restrooms and micro-mobility services can change the livability perception of older and less active residents, especially for longer distances and in times of extreme cold or heat (Zaffagnini et al., 2022). In suburban areas, motorised vehicle reliance of older age groups reveals an interplay between (public) transport infrastructure and vehicle ownership (Lord et al., 2011). In the case of Norwegian transport nodes, Knapskog et al. (2019) concluded that measures reducing car accessibility and increasing walkable infrastructure would increase walkability also in the neighbourhoods that surround established transport nodes. Finally, transport accessibility as defined by Bok and Kwon (2016) "is characterized by the ease with which inhabitants can reach means of transportation such as buses or metros."

Finally, Goel (2023) reflected on the gender gap in daily living practices, especially in mobility patterns. The author concludes that significant gender and age gaps existed in day-to-day presence at home. Many socio-demographic and -economic variables lead to a lower mobility of women.

A.5.3. Economic relations impacts

How Vanclay (2002) establishes the SI economic impacts is shown in Table A.1 in Appendix A.1. Next to the standard of living, the employment options available and the dependent income and occupational status, the economic resilience, dependence and workload are impacts within this category. Additionally, the access to public or governmental goods and (social) services forms part of the economic impact category. Lastly, property values as major factor for economic standing, the local and national economy stability are considered.

As mentioned in subsection A.5.1, thermal stress can reduce human performance. As a consequence thermal stress has impacts on the economic productivity of workers and may pose a financial risk factor (Enander & Hygge, 1990; Lan et al., 2010; Parsons, 2019). Anticipating CC, an urban heat resilience based on air conditioning should not be opted for. Instead, Moore et al. (2017) proposes the exploration of natural ventilation to increase summer thermal comfort of residents on the one hand and to maintain living expenses for electricity use on lower levels. However, as modelled by L. Liu et al. (2023), changes in climate scenarios will disproportionately affect low latitudes due to increasing cooling energy demand. Energy sectors in northern middle to high latitudes would experience "smaller and more variable supply" (L. Liu et al., 2023, p.1), which would be alleviated by reduced heating demand in the colder seasons in these areas. Their research underlines the importance of the consideration of local contexts - but also the inequality in the consequences of CC. For this project I conclude that increases in energy demand, for cooling as well as heating, stresses household incomes and standards of living.
In contrast to the effects of heat, Thomas et al. (2012) evaluate how floods may affect not only the health of urban residents, but also can lead to loss of productivity and income at the household level. Indirectly, this may propagate adverse impacts on health.

Looking at another aspect of CCA, the cost of drainage infrastructures was considered i.a. by Seyedashraf et al. (2022). The authors found that environmentally sustainable urban drainage systems might reproduce urban inequalities. This would especially be the case if spatial inequalities and the spatial distribution of drainage infrastructure were not considered. They point out, that this was often not the case as the main criteria in the planning of locations for such infrastructure was cost-effectiveness and reliability. In their review, Kourtis and Tsihrintzis (2021), further emphasise the uncertainty of CC

impacts on water management systems - which challenges the cost-accounting and resilience of such systems in the future.
One of the major budget posts, urban drainage infrastructure is highly stressed due to urban form change and CC. Urban drainage systems represent the most expensive capital investment in infrastructure in cities and the most cost-effective in terms of socio-economic gain. Property values are subject to the effectiveness or in-effectiveness of the drainage systems (Lund et al., 2019).

Like drainage systems does the cost-effectiveness of green space in urban areas fall under the impact of CC scenarios. Especially the maintenance of such spaces requires financial upkeep. Their height is difficult to predict for uncertain climate trajectories and exposes savings and public budgets (Reu Junqueira et al., 2023). This fact deteriorates urban equality if the work of Kolimenakis et al. (2021) is considered. The authors review research on the link between urban green space and socioeconomic situation. They find that green space existence in urban areas can be decisive for property values. What is more, green space would increase the welfare levels of the residents.

A household's income level is detrimental. In the context at hand, the review of Levesque et al. (2021) concludes that household income level changes affects the health of children and adolescents. The socioeconomic status of households correlates, for instance, with physical and dental health

Next to a family's ability to pay for education, income levels and affluence may determine a person's access to mobility options and urban transportation. This effect has been coined transportation poverty or mobility poverty. In their case study for Bogotá, Guzman et al. (2017) concluded that socioeconomic structure and income in an area affect the spatial distribution of transport infrastructure. Thereby, transport mode availability influences the accessibility to employment options and education in the city. The effect of households' incomes and standard of living is thereby two-fold: first, the ability to pay for available transportation may decrease with lower incomes. second, this availability and existence of transportation modes may itself depend on the area's socio-economic standing. Similar results were suggested by Furszyfer Del Rio et al. (2023). In their assessment of mobility as well as energy systems for three case study countries, Ireland, the United Arab Emirates as well as Mexico, they found that equal access to these systems was defined by the height of the income. Also for the South Asian and Middle East and North Africa (MENA) region cities, mobility mode choice behaviour of residents correlates with socioeconomic status and vehicle ownership (Chaudhry et al., 2023).

How urban infrastructure transitions potentially impact access to public and government services can be derived from the work of Ramaswami et al. (2021). The authors discuss the importance of urban infrastructure transition agendas, such as smart city, compact city, electric mobility, nature-based solutions, food-action, and climate adaptation planning. These agendas recognize that infrastructure and land-use planning are interlinked and undertaken for households and businesses together. This implies that the urban form and morphology can influence the access to public and government services. Moreover, they might affect the residents' standard of living, and economic dependency.

Lastly, I want to name the findings of Toboso-Chavero et al. (2021) to reflect on the discrepancy between CCM benefits and residents' preferences. In their case study they looked at Barcelona residents' choices of rooftop usage. From the perspective of life-cycle carbon reduction potential, vegetable production would have provided the largest potential, but residents referred to high energy prices. As they struggled with the payments, their preference would be to generate energy or harvest rainwater on rooftops, not to grow their own food. While not representative, this article sheds light on the gap between economic and environmental cost-effectiveness and questions the awareness of urban planners and science for residents' struggles.

A.5.4. Culture relations impacts

As with the other SI's the social impacts included into this category are the compiled in Appendix A.1. They comprise cultural values, natural and cultural heritage loss. But also issues related to identity, such as cultural integrity, marginalisation and profanisation. Language loss and cultural affrontage might also arise in this SI.

In the broader perspective, many aspects of this SI are highly related to the inclusion or exclusion (discrimination) of urban resident groups as well as changes in urban form affecting cultural values.

In the general context of sustainability, Koutra et al. (2018) highlight the increasing awareness of academia about CC and its impacts, generating demand for more sustainable and transparent tools and systems. This awareness and the resulting changes in urban systems could lead to shifts in cultural values towards more sustainable practices. On the other hand, this could potentially infringe on cultural integrity if these shifts are not inclusive of all cultural groups or if they do not respect and preserve cultural heritage.

In 2022, Z. Liu et al. (2022) discussed the importance of considering CC in the design of urban energy systems. They highlight the need for robust systems that can provide stable power to consumers despite the uncertainties of CC. This has implications for cultural values as stable power supply is crucial for maintaining urban lifestyles and preserving cultural heritage sites that rely on electricity. Changes in power stability could affect various cultural aspects, from the operation of cultural heritage sites to everyday practices. These changes could potentially marginalize certain cultural practices or groups that are heavily reliant on stable power supply.

Changes in building design and operation might alter the aesthetic and functional aspects of urban landscapes. On the building level, Hosseini et al. (2022) emphasize the role of buildings in achieving flexible and resilient urban energy solutions which are necessary for the ET. The authors argue that accurate assessment of energy performance is necessary for CCA in urban areas. As building design are an essential part of cultural aesthetics and landscapes, such changes could impact cultural values. Additionally, this could lead to cultural marginalization if these changes do not take into account the cultural significance of certain urban forms or if they disproportionately affect certain cultural groups in the urban sphere in question.

Likewise, Mauree et al. (2019) assess how CC can affect renewable energy generation, particularly wind, hydropower, and solar energy. They suggest that the integration of renewable energy in urban areas will provide new opportunities for urban energy systems. Moreover, Phelan et al. (2015) regard the effects of urban climate and CC on energy systems and infrastructure. They suggest that decentralized on-site energy production and use in urban areas could minimize energy transmission loss. These interventions could lead to changes in urban landscapes, potentially impact cultural heritage sites and thereby, impact cultural values and heritage.

A.5.5. Family and community impacts

How Vanclay (2002) establishes the SI family and community impacts is shown in Table A.1 in Appendix A.1. Impacts in the sphere of family are alterations of family structures and sexual relations, obligations to living elders or the occurrence of family violence. In the broader, community sphere, disruption of social networks, changed demographics in the community, or the identification with and connection to this community, as well ass the perceived or actual community cohesion and social tension and violence are part of this category. Lastly, social differentiation and inequity belongs to this group. In the analysis, I draw a connection from this final impact to the SI category of institutional, legal, political and equity impacts as social differentiation can have highly institutionalised roots based on intersectionality and inequality.

Expanding the notion of access to mobility modes, given in subsection A.5.3, Böcker et al. (2017) point out that the increased mobility of the elderly population has to be taken into account in urban planning. The changed demographic structure of the community may lead to a second order impact for the community. Increased levels of elderly mobility need to be considered in urban planning to prevent social differentiation and inequity. Moreover, the need for support through family members and thereby obligations to living elders might be decreased if the autonomy of elderly groups is maintained.

The impacts of transportation systems on neighbourhoods was also subject in the study of Nilsson and Delmelle (2018). The authors call for a thorough consideration and necessary knowledge of neighbourhood dynamics before the opening of a transit station. Such investments could lead to stronger changes in socioeconomic and demographic constellations in lower-income or impoverished neighbourhoods than in more affluent neighbourhoods. The social fabric would thereby experience a higher probability of changes in already disadvantaged areas.

Social differentiation and inequity can also be increased due to low access levels to amenities and public services. As Du et al. (2021) elaborate, the provision of amenities such as supermarkets, green spaces, transport and walkable built environments is subject to spatial inequalities and socio-economic disparities of ethnic, gender, income and age groups. In the context of urban green space, Dai (2011)

concluded that urban inequality due to racial segregation lowered the access of African-American resident neighbourhoods to urban green space in the USA. Also Juntti and Ozsezer-Kurnuc (2023) find that urban planning, policy and establishment of urban nature does not affect urban residents equally but correlates with complex relationships of inequality. An alleviation of this effect is subject of Du and Zhang (2020). The authors suggest that a higher number of small green space patches may increase social and economic equality in contrast to the effect that a few large green spaces may be able to generate.
Within the realm of CCA, several relationships have been conceptualised: The association of flood risk and susceptibility has been described by D'Aragon (2013) in their work on resilience building amongst poor urban communities. D'Aragon (2013) concludes that the tendency of disadvantageous locations of the land that is used by poor urban residents gives way for a higher susceptibility of flood risks related to insufficient drainage as well as unsafe potable water conditions in low-lying areas. Similarly, Machairas and van de Ven (2023) zoomed into the relationship between groundwater and social differentiation. They stated that next to land use and monumental locations, low income may contribute to the vulnerability to groundwater droughts in the Netherlands. Finally the studies of Mobini et al. (2020) and Cea and Costabile (2022) highlight inequalities in the link between flood risks and flood consequences and social inequality and differentiation.

Another subject to social differentiation may be households affected by energy poverty. As SDG 7 aims at access to affordable, reliable and modern energy for all, the phenomenon of energy poverty may be defined by whether the necessary energy can be afforded with the income at hand. The simplest manifestation may lie in the ability to pay for energy bills due to energy prices. Another aspect is whether the home is of good energetic quality (reducing heating or cooling costs) or renewable energy sources are accessible (Bouzarovski, 2014; International Energy Association (IEA), 2021; Primc & Slabe-Erker, 2020). If residential location is associated with housing stock quality, this can increase energy bills for the tenants and even determine inequalities between communities if lower income households are pushed to make residential choices in line with energy affordability (Großmann et al., 2014). Households with lower income and educational levels may be more susceptible to energy poverty (Best & Sinha, 2021; Xie et al., 2022).

In the case of the Netherlands, Mulder et al. (2023) found that the income level determines the participation in the energy transition. Next to this, the housing stock might be of reduced quality. The authors find that especially tenants and low-wealth/-income home owners from the participation in the energy transition. Residents who are not homeowners are not reached by public subsidies which aim at the upgrade of housing quality. As a result, energy poverty may lead to other social impacts, such as health issues, debt, and loneliness when energy poverty leads to social exclusion and differentiation (Mulder et al., 2023).

How social quality is influenced through built structures has been a topic in urban design and planning for decades (Dempsey, 2008). Communities in neighbourhoods and how social cohesion and sense of community may be fostered or distorted is of interest in many fields (the same counts for "livability" of the built environment) (Dempsey, 2008). Which urban design elements are fostering social sustainability in urban renewal has been the subject of a survey in Yıldız et al. (2020). In general, the multi-functionality, walkability, lower commuting times associated with densified urban development may be beneficial to social interaction. Multi-functionality and walking may create spaces for interaction of various social groups, and shortened travel times might open up recreational activities and caring for social relationships in communities. This has been promoted in the New Urbanist paradigm (Mazumdar et al., 2018). However, the outcome is highly complex and, also driven by the residents itself. Increased social interaction might on the downside also increase social friction, tension or even crime (Mazumdar et al., 2018).

Not at least the COVID-19 pandemic exposed the vulnerabilities of population groups that are more inclined to stay at home. If social norms (or social or health restrictions) bind a person to the home, one of the potential consequences may be a stronger social differentiation and community disconnect. Other impacts might affect the resident's health, well-being (Marroquín et al., 2020) or participation in decision-making processes. For vulnerable groups subjected to violence, staying at home may increase the risk to be subject of violence (Kaukinen, 2020; Piquero et al., 2020).

Lastly, the impacts of energy prices and CCA, especially in hotter climates might reduce the individual's thermal comfort. These impacts give reason to believe that outdoor social interaction may strengthen community connect, residents' health, and social quality and networks.

A.5.6. Institutional, legal, political and equity impacts

How Vanclay (2002) establishes the SI health is shown in Table A.1 in Appendix A.1: This category includes the workload and viability of (non- or) government agencies or informal agencies, and community organisations, as well as the integrity of government and government agencies. Access to legal procedures and advice or the loss of tenure, legal rights or subsidiarity and the violation of human rights are accounted for in this SI. Participation in decision-making and the notions about fairness in the distributions of impacts across the community ("impact equity") are part of the institutional, legal, political and equity SI.

The impact capacity of public participation in urban planning procedures and vice versa, the impact of urban planning processes on the ability to participate in decision-making processes has been described as largely dependent on personal traits and socio-economic characteristics (Solitare, 2005). Considering that public participation processes require resources and commitment from government agencies and public alike, participation in decision-making can only happen where these resources exist. Indoor heat stress has been described as unequally affecting socio-demographic groups, inhibiting their participation (Lundgren Kownacki et al., 2019).
Notions about the fairness and equity of urban planning interventions are largely connected to the opportunity of participation in decision-making as well as the general trust and the planning agency. Cooperative planning with the inclusion of affected citizens has also been assessed as more likely to lead to urban planning interventions in the public interest (Gunton & Day, 2003). Planning bias (or estimated planning bias) can vastly hamper the perception of an urban development as equitable.
Finally, Levine (2017) explored the crucial power capacity of public participation meeting. Their findings claim that even though the number of community meetings in neighbourhoods are high, this in frequent cases merely suggests power. The actual decision-making capacity in the observation at hand still lay with the authority officials. Therefore, these increased numbers of neighbourhood meetings in this context were only leading to pretended decision-making power due to citizen participation. As this is highly context-specific and cannot be generalised, the circumstances of each case need to be assessed and the actual contribution due to public participation monitored.

A.5.7. Gender relations impacts

How Vanclay (2002) establishes the SI gender relations is shown in Table A.1 in Appendix A.1: next to women's physical integrity, personal autonomy and political emancipation, the equity of educational achievement between girls and boys is a component to this SI. The gendered division of production-oriented labour, household labour, reproductive labour as well as the gender-based control over and access to resources and services are part of this SI.
I want to make the disclaimer that due to the availability of time and literature I have to base this SI on a binary gender understanding.

Linked with the SI livability, female leisure time is designed differently than the leisure activities of males. Male study participants reported a higher frequency of physical activity during leisure time. This included the use and appropriation of public space (Castro-Carvajal et al., 2008). In addition to these preferences, the lack of time to practice physical activity during leisure times posed an impediment to female recreation. In contrast to male participants, women's outdoor activities did not show a correlation with green space percentages and number of benches in a neighbourhood (Akinci et al., 2021). Importantly, for their case study in China, Xiong (2019) could discern a potential positive relationship between outdoor exercise space constructed for women and health, well-being, social network formation, participation and autonomy of female users.

In terms of the gendered division of household and reproductive labour, Scheiner (2016) and Oakil et al. (2016) investigated the link between gender, care-work and commuting behaviour. Scheiner (2016) identified a disproportionate difference in the carrying of escorting behaviour of school children (even though adolescents in urban areas had been identified as more independent than adolescents in rural areas). In larger cities, fathers took on more escorting tasks. In the study of Oakil et al. (2016), a tendency of female rush hour travel was described. The reason for higher rush hour participation of women in the mornings were household activities and child chauffeuring. In the afternoons, childcare activities pushed women to commute during rush hours. This gendered commuting behaviour suggests several second order impacts, such as increased travel price, discomfort during the trip or decreased autonomy of women. In particular specified for heterosexual relationships, Gil Solá (2016) reported household "contracts" which may influence the implications of work travel for the members of the household, depending on the mutual perception of the relationship. The importance of gendered mobility planning was raised by Porrazzo et al. (2022). They found that non-gendered urban planning, as well as the assumption of equality alone may pose a barrier to gender sensitive mobility planning and eventually increase gender inequality.

Stark and Meschik (2018) concluded that a high share of women is faced with frightening situations, i.e. situations causing fear and/or harassment, in their daily routines. For this reason, women may constrain their travel behaviour. This conclusion can be interpreted as the influence of perceived or actual safety of women on mobility choices, and thereby diminishing female autonomy, increasing daily routine disruption and lastly, gender inequality. Overlapping with social stigmatisation and cultural marginalisation, Johnson and Miles (2014) assessed public transport access and walkability from the standpoint of female residents who are wearing Islamic headscarves. In neighbourhoods with a higher number of other female residents also carrying headscarves for religious reasons, as well as in areas with better lighting and openness of space, the study participants reported a larger participation in the public life.

Cultural tendencies of women to stay within the home also influence their health and vulnerability. For the case of heat and thermal comfort, Neumayer and Plümper (2007) depicted that everyday social norms and the family's socioeconomic status were detrimental. Such gendered immobility increased natural disaster and thermal discomfort susceptibility.

Appendix B

Literature Review

B.1. Search strategy

Phase/step	Step-ID	Type	Item
Search Strategy	1	decision	define search goal
	2	process	create concept map
	3	decision	define applicable review type
	4	decision	scope: geographic, temporal, methodological, literature type
	5	decision	decision database(s)
	6	decision	define search themes
	7	process	setup search documentation table
Identification	8	process	create list/folder in reference manager per theme
			per database and theme
	9	process	define search strings
	10	process	test search strings
	11	decision	revise search strings, criteria: applicability and feasibility to manage the results
	12	process	collect search results, append results to list
Screening	13	process	remove duplicates
	14	decision	number of results
	if ASR: ASR1	process	ASR: train relevant/irrelevant
	ASR2	process	ASR: screen titles and abstracts for applicability, scope
	ASR3	process	ASR: exlusion of non-applicable works
	ASR4	decision	ASR: saturation
	15	process	screen titles and abstracts for applicability, scope
	16	decision	exlusion of non-applicable works and document a summary of exclusion reasons
Eligibility	17	process	assess full-text articles for eligibility
	18	decision	exclusion of non-eligible works
	19	decision	add work to theme literature list
Inclusion			Both databases and all themes
	20	decision	add records through snowballing, forward, backwards...
			total number studies included

B.2. Search queries and number of results

Theme			Scopus			Web of Science			Total
theme	string ID	search string	# results	search date	appended to	# results	new appended	search date	Total/string
general									
		"compact city" AND "climate change adaptation"	7	9-7-2023	CCA-general list	5	0	10-8-2023	7
		densification AND city OR urban AND "climate change adaptation"	13	9-7-2023	CCA-general list	7	1	10-8-2023	14
thermal comfort									
		"compact city" AND "thermal comfort"	16	9-7-2023	CCA-thermal list	6	0	10-8-2023	16
		densification AND city OR urban AND "thermal comfort"	24	9-7-2023	CCA-thermal list	16	1	10-8-2023	25
flooding									
		"compact city" AND "flooding"	16	9-7-2023	CCA-flooding list	20	5	10-8-2023	21
		densification AND city OR urban AND "flooding"	39	9-7-2023	CCA-flooding list	38	21	10-8-2023	60
		inundation AND "compact city"	1	9-7-2023	CCA-flooding list	0			1
freshwater/drought									
		"compact city" AND freshwater OR drought	4	9-7-2023	CCA-freshwater list	2	0	10-8-2023	4
		densification AND city OR urban AND freshwater OR drought	10	9-7-2023	CCA-freshwater list	9	0	10-8-2023	10
rainfall									
		"compact city" AND rain OR precipitation	8	9-7-2023	CCA-freshwater list	2	0	10-8-2023	8
			29	9-7-2023	CCA-freshwater list	14	0	10-8-2023	29
total per database			167				28		
TOTAL/transition									195
complementary									
management									
	resilience								
		"compact city" AND "climate change" AND "resilience"	13	9-7-2023					
		densification AND city OR urban AND "climate change" AND resilience	18	9-7-2023					
	risk plan OR management								
		"compact city" AND "climate change" AND "management"	16	9-7-2023					
		densification AND city OR urban AND "climate change" AND management	47	9-7-2023					
	dissemination								
		"compact city" AND "climate change" AND "dissemination" OR education	1	9-7-2023					
		densification AND city OR urban AND "climate change" AND dissemination	1	9-7-2023					
CC									
		~~"compact city" AND "climate change"~~	~~97~~	9-7-2023					
		~~densification AND city OR urban AND "climate change"~~	~~136~~	9-7-2023					
	flooding								
		flooding AND density AND urban	535	9-7-2023					
		inundation AND density AND urban	111	9-7-2023					
		flooding AND 'urban AND development'	3117	9-7-2023					
		flooding AND 'urban AND development' AND density	185	9-7-2023					
		flooding AND 'urban AND form'	475	9-7-2023					
	rain/precipitation								
		density AND city OR urban AND rain OR precipitation	1944	9-7-2023					

Theme			Scopus			Web of Science			Total
Theme-Group	string ID	search string	# results appended	search date	list	# results	new appended	search date	Total/string
mobility									
	E1	"compact city" AND transport AND energy	51	06.06.2023	energy-mobility list	28	3	31.07.2023	54
	E2	"compact city" AND transport AND transition	15	06.06.2023	energy-mobility list	8	1	31.07.2023	16
	E3	densification AND transport AND energy AND urban OR city	31	06.06.2023	energy-mobility list	23	3	31.07.2023	34
	E4	~~"compact city" AND mobility~~	~~113~~		~~not appended~~				~~113~~
	E5	"compact city" AND mobility AND transition	6	06.06.2023	energy-mobility list	5	0	31.07.2023	6
	E6	"compact city" AND mobility AND energy	27	06.06.2023	energy-mobility list	14	2	31.07.2023	29
	E7	~~densification AND mobility AND urban OR city~~	~~102~~		~~not appended~~				102
	E8	densification AND mobility AND energy AND urban OR city	21	06.06.2023	energy-mobility list	9	1	31.07.2023	~~22~~
	E9	"compact city" AND cycling AND mobility	6	06.06.2023	energy-mobility list	6	2	31.07.2023	8
	E10	~~"compact city" AND cycling AND transition~~	1	06.06.2023	~~not appended~~				~~1~~
	E11	densification AND cycling AND energy AND urban OR city	1	06.06.2023	energy-mobility list	9	3	31.07.2023	4
	E12	"compact city" AND walking	48	06.06.2023	energy-mobility list	38	6	31.07.2023	54
	E13	"compact city" AND walking AND energy	4	06.06.2023	energy-mobility list	4	0	31.07.2023	4
	E14	~~"compact city" AND walking AND transition~~			~~not appended~~				
	E15	densification AND walking AND energy AND urban OR city	4	06.06.2023	energy-mobility list	3	0	31.07.2023	4
	E16	densification AND walking AND urban OR city	48	06.06.2023	energy-mobility list	25	18	31.07.2023	66
Energy and housing/residential cooling/heating									
	E17	"compact city" AND housing OR residential OR household AND cooling OR heating	10	09.06.2023	energy-cooling/heating list	7	2	31.07.2023	14
	E18	densification AND urban OR city AND housing OR residential OR household AND cooling OR heating	22	09.06.2023	energy-cooling/heating list	20	4	31.07.2023	26
	E19	"compact city" AND housing OR residential OR household AND cooling OR heating AND energy	8	09.06.2023	energy-cooling/heating list	5	0	31.07.2023	13
	E20	densification AND urban OR city AND cooling OR heating AND energy	41	09.06.2023	energy-cooling/heating list	34	5	31.07.2023	46
	E21	"compact city" AND housing OR residential OR household AND "electricity generation" OR "energy generation"	1	09.06.2023	energy-production list	1	0	31.07.2023	2
	E22	densification AND urban OR city AND "electricity generation" OR "energy generation"	5	09.06.2023	energy-production list	8	1	03.08.2023	6
	E23	"compact city" AND cooling OR heating	31	09.06.2023	energy-cooling/heating list	53	19	03.08.2023	46
	E24	densification AND urban OR city AND cooling OR heating	64	09.06.2023	energy-cooling/heating list	98	15	03.08.2023	79
Urban energy production									
	E25	"compact city" AND electricity OR energy AND photovoltaic OR wind OR geothermal OR "heat pump" OR gas OR coal OR hydrogen	44	28.06.2023	energy-production list	21	1	03.08.2023	44
	E26	densification AND urban OR city AND electricity OR energy AND photovoltaic OR wind OR geothermal OR "heat pump" OR gas OR coal OR hydrogen	39	28.06.2023	energy-production list	24	0	03.08.2023	39
	E27	"compact city" AND housing OR residential OR household AND "electricity generation" OR "energy generation"	1	28.06.2023	energy-production list	0	0	03.08.2023	1
	E28	densification AND urban OR city AND "electricity generation" OR "energy generation"	5	28.06.2023	energy-production list	1	0	03.08.2023	5
Urban energy grid									
	E29	"compact city" AND electricity OR energy AND infrastructure OR grid OR network OR hub	54	28.06.2023	energy grid list	25	4	03.08.2023	57
	E30	densification AND urban OR city AND electricty OR energy AND infrastructure OR grid OR network OR hub	61	28.06.2023	energy grid list	44	3	03.08.2023	64

B.3. Inclusion and exclusion criteria

Overview of inclusion and exclusion criteria applied.

Topic	inclusion	exclusion
Conceptual/ Definition	reflected in the CM	nothing with... e.g. fluid density, precipitation in solutions,..
	reflected in SI	
item type	articles, other: only exceptions	
language	English, other: only exceptions	
accessibility	needs to be accessible with TU Delft access	
fields	processes observed from diversity of fields in the urban sphere, focus on natural sciences, engineering, urban development	no economic policy, no chemical engineering
region	global	
ASReview	decisions and labelled training data can be obtained from author upon request	

B.4. Author-centric data set

Supplementary information:

- Literature review items: excel file Workbook AppendixB.4.AuthorCentricDataSet

Table B.1: Publication years, authors and titles of the collected literature review items.

Publication Year	Author	Title
2014	Adachi, Sachiho A.; Kimura, Fujio; Kusaka, Hiroyuki; Duda, Michael G.; Yamagata, Yoshiki; Seya, Hajime; Nakamichi, Kumiko; Aoyagi, Toshinori	Moderation of Summertime Heat Island Phenomena via Modification of the Urban Form in the Tokyo Metropolitan Area
2015	Adetokunbo, Ilesanmi; Emeka, Mgbemena	Urbanization, Housing, Homelessness and Climate Change
2019	Ahmadian, Ehsan; Byrd, Hugh; Sodagar, Behzad; Matthewman, Steve; Kenney, Christine; Mills, Glen	Energy and the form of cities: the counterintuitive impact of disruptive technologies
2022	Allan, J.; Eggimann, S.; Wagner, M.; Ho, Y.N.; Züger, M.; Schneider, U.; Orehounig, K.	Operational and embodied emissions associated with urban neighbourhood densification strategies
2012	Arnberger, Arne	Urban Densification and Recreational Quality of Public Urban Green Spaces—A Viennese Case Study
2023	Back, Y.; Kumar, P.; Bach, P.M.; Rauch, W.; Kleidorfer, M.	Integrating CFD-GIS modelling to refine urban heat and thermal comfort assessment
2022	Bakhshoodeh, Reza; Ocampo, Carlos; Oldham, Carolyn	Exploring the evapotranspirative cooling effect of a green façade
2019	Barbosa, G.S.; Drach, P.R.C.; Corbella, O.D.	Intraurban temperature variations: Urban morphologies of the densification process of copacabana neighborhood, Brazil

Table B.1 continued from previous page

2019	Belcher, R.N.; Suen, E.; Menz, S.; Schroepfer, T.	Shared landscapes increase condominium unit selling price in a high-density city
2016	Bobylev, N.	Underground space as an urban indicator: Measuring use of subsurface
2023	Brom, P.; Engemann, K.; Breed, C.; Pasgaard, M.; Onaolapo, T.; Svenning, J.-C.	A Decision Support Tool for Green Infrastructure Planning in the Face of Rapid Urbanization
2020	Bruwier, Martin; Maravat, Claire; Mustafa, Ahmed; Teller, Jacques; Pirotton, Michel; Erpicum, Sébastien; Archambeau, Pierre; Dewals, Benjamin	Influence of urban forms on surface flow in urban pluvial flooding
2020	Butters, Chris; Cheshmehzangi, Ali; Sassi, Paola	CITIES, ENERGY AND CLIMATE: SEVEN REASONS TO QUESTION THE DENSE HIGH-RISE CITY
2012	Byrd, H.; Ho, A.	Transport energy and city density: A case study of how renewable energy can reverse the curve
2013	Byrd, H.; Ho, A.; Sharp, B.; Kumar-Nair, N.	Measuring the solar potential of a city and its implications for energy policy
2016	Byrne, J.; Ambrey, C.; Portanger, C.; Lo, A.; Matthews, T.; Baker, D.; Davison, A.	Could urban greening mitigate suburban thermal inequity?: The role of residents' dispositions and household practices
2013	Clark, T.A.	Metropolitan density, energy efficiency and carbon emissions: Multi-attribute tradeoffs and their policy implications
2001	Cooper, J.; Ryley, T.; Smyth, A.	Energy trade-offs and market responses in transport and residential land-use patterns: Promoting sustainable development policy
2020	Delgado-Capel, M.; Cariñanos, P.	Towards a standard framework to identify green infrastructure key elements in dense mediterranean cities
2023	Deng, X.; Cao, Q.; Wang, L.; Wang, W.; Wang, S.; Wang, S.; Wang, L.	Characterizing urban densification and quantifying its effects on urban thermal environments and human thermal comfort

Table B.1 continued from previous page

2018	Duy, P.N.; Chapman, L.; Tight, M.; Linh, P.N.; Thuong, L.V.	Increasing vulnerability to floods in new development areas: evidence from Ho Chi Minh City
2023	Erlwein, Sabrina; Meister Juliane; Wamsler, Christine; Pauleit, Stephan	Governance of densification and climate change adaptation: How can conflicting demands for housing and greening in cities be reconciled?
2021	Erlwein, Sabrina; Pauleit,Stephan	Trade-Offs between Urban Green Space and Densification: Balancing Outdoor Thermal Comfort, Mobility, and Housing Demand
2018	Everett, G.; Lamond, J.e.; Morzillo, A.t.; Matsler, A.m.; Chan, F.k.s.	Delivering Green Streets: an exploration of changing perceptions and behaviours over time around bioswales in Portland, Oregon
2022	Fassbender, E.; Ludwig, F.; Hild, A.; Auer, T.; Hemmerle, C.	Designing Transformation: Negotiating Solar and Green Strategies for the Sustainable Densification of Urban Neighbourhoods
2022	Fitobór, K.; Ulańczyk, R.; Kołecka, K.; Ramm, K.; Włodarek, I.; Zima, P.; Kalinowska, D.; Wielgat, P.; Mikulska, M.; Antończyk, D.; Krzaczkowski, K.; Łyszyk, R.; Gajewska, M.	Extreme weather layer method for implementation of nature-based solutions for climate adaptation: Case study Słupsk
2023	Gadish, I.; Saaroni, H.; Pearlmutter, D.	A predictive analysis of thermal stress in a densifying urban business district under summer daytime conditions in a Mediterranean City
2018	Govehovitch, Benjamin; Giroux-Julien, Stéphanie; Peyrol, Éric; Ménézo, Christophe	Building Integrated Photovoltaic (PV) Systems: Energy Production Modeling in Urban Environment
2021	Grunwald, Laura; Weber, Stephan	Influence of urban land-use change on cold-air path occurrence and spatial distribution
2005	Holden, E.; Norland, I.T.	Three challenges for the compact city as a sustainable urban form: Household consumption of energy and transport in eight residential areas in the Greater Oslo Region

Table B.1 continued from previous page

2021	Juan, Yu-Hsuan; Wen, Chih-Yung; Li, Zhengtong; Yang, An-Shik	Impacts of urban morphology on improving urban wind energy potential for generic high-rise building arrays
2021	Kabisch, N.; Kraemer, R.; Brenck, M. E.; Haase, D.; Lausch, A.; Luttkus, M. L.; Mueller, T.; Remmler, P.; von Döhren, P.; Voigtländer, J.; Bumberger, J.	A methodological framework for the assessment of regulating and recreational ecosystem services in urban parks under heat and drought conditions
2022	Kang, Seungwon; Lee, Dalbyul; Park, Jiyong; Jung, Juchul	Exploring Urban Forms Vulnerable to Urban Heat Islands: A Multiscale Analysis
2020	Kaza, N.	Urban form and transportation energy consumption
2021	Khavarian-Garmsir, Amir Reza; Sharifi, Ayyoob; Moradpour, Nabi	Are high-density districts more vulnerable to the COVID-19 pandemic?
2020	Kii, M.	Reductions in CO2 emissions from passenger cars under demography and technology scenarios in Japan by 2050
2015	Kleerekoper, L.; van den Dobbelsteen, A.A.J.F.; Hordijk, G.J.; van Dorst, M.J.; Martin, C.L.	Climate adaptation strategies: Achieving insight in microclimate effects of redevelopment options
2017	Ko, Yekang; Jang, Kitae; Radke, John D.	Toward a solar city: Trade-offs between on-site solar energy potential and vehicle energy consumption in San Francisco, California
2018	Kokkonen, T.V.; Grimmond C.S.B.; Christen, A.; Oke, T.R.; Järvi, L.	Changes to the Water Balance Over a Century of Urban Development in Two Neighborhoods: Vancouver, Canada
2018	Koopmans, Sytse; Ronda, Reinder; Steeneveld, Gert-Jan; Holtslag, Albert A. M.; Klein Tank, Albert M. G.	Quantifying the Effect of Different Urban Planning Strategies on Heat Stress for Current and Future Climates in the Agglomeration of The Hague (The Netherlands)
2015	Lemonsu, A.; Viguié, V.; Daniel, M.; Masson, V.	Vulnerability to heat waves: Impact of urban expansion scenarios on urban heat island and heat stress in Paris (France)
2021	Li, X.; Erpicum, S.; Mignot, E.; Archambeau, P.; Pirotton, M.; Dewals, B.	Influence of urban forms on long-duration urban flooding: Laboratory experiments and computational analysis

Table B.1 continued from previous page

2012	Liu, X.; Sweeney, J.	Modelling the impact of urban form on household energy demand and related CO 2 emissions in the Greater Dublin Region
2021	Loibl, W.; Vuckovic, M.; Etminan, G.; Ratheiser, M.; Tschannett, S.; Österreicher, D.	Effects of densification on urban microclimate —a case study for the city of Vienna
2014	Martilli, A.	An idealized study of city structure, urban climate, energy consumption, and air quality
2022	Martínez Reverte, Irene; Gómez-Navarro, Tomás; Sánchez-Díaz, Carlos; Montagud Montalvá, Carla	Evaluation of Alternatives for Energy Supply from Fuel Cells in Compact Cities in the Mediterranean Climate; Case Study: City of Valencia
2020	Mielby, S.; Henriksen, H.J.	Hydrogeological studies integrating the climate, freshwater cycle and catchment geography for the benefit of urban resilience and sustainability
2017	Miner, Mark J; Taylor, Robert A; Jones, Cassandra; Phelan, Patrick E	Efficiency, economics, and the urban heat island
2020	Moebus, Susanne; Gruehn, Dietwald; Poppen, Jonas; Sutcliffe, Robynne; Haselhoff, Timo; Lawrence, Bryce	Akustische Qualität und Stadtgesundheit – Mehr als nur Lärm und Stille
2019	Mohajeri, N.; Perera, A.T.D.; Coccolo, S.; Mosca, L.; Le Guen, M.; Scartezzini, J.-L.	Integrating urban form and distributed energy systems: Assessment of sustainable development scenarios for a Swiss village to 2050
2023	Mohajeri, Nahid; Walch, Alina; Smith, Alison; Gudmundsson, Agust; Assouline, Dan; Russell, Tom; Hall, Jim	A machine learning methodology to quantify the potential of urban densification in the Oxford-Cambridge Arc, United Kingdom
2022	Moravej, M.; Renouf, M.A.; Kenway, S.; Urich, C.	What roles do architectural design and on-site water servicing technologies play in the water performance of residential infill?
2021	Morelli, A.B.; Cunha, A.L.	Measuring urban road network vulnerability to extreme events: An application for urban floods
2019	Mouratidis, Kostas	Compact city, urban sprawl, and subjective well-being

Table B.1 continued from previous page

2018	Mouratidis, Kostas	Is compact city livable? The impact of compact versus sprawled neighbourhoods on neighbourhood satisfaction
2020	Mughal, M. O.; Li, Xian-Xiang; Norford, Leslie K.	Urban heat island mitigation in Singapore: Evaluation using WRF/multilayer urban canopy model and local climate zones
2020	Muñiz, I.; Dominguez, A.	The impact of urban form and spatial structure on per capita carbon footprint in u.S. larger metropolitan areas
2019	Muñiz, I.; Rojas, C.	Urban form and spatial structure as determinants of per capita greenhouse gas emissions considering possible endogeneity and compensation behaviors
2014	Næss, Petter	Urban Form, Sustainability and Health: The Case of Greater Oslo
2021	Oliveira, A.; Lopes, A.; Correia, E.; Niza, S.; Soares, A.	An urban climate-based empirical model to predict present and future patterns of the Urban Thermal Signal
2022	Palusci, Olga; Monti, Paolo; Cecere, Carlo; Montazeri, Hamid; Blocken, Bert	Impact of morphological parameters on urban ventilation in compact cities: The case of the Tuscolano-Don Bosco district in Rome
2023	Perera, A. T. D.; Javanroodi, Kavan; Mauree, Dasaraden; Nik, Vahid M.; Florio, Pietro; Hong, Tianzhen; Chen, Deliang	Challenges resulting from urban density and climate change for the EU energy transition
2019	Pierer, Carl; Creutzig, Felix	Star-shaped cities alleviate trade-off between climate change mitigation and adaptation
2022	Pramanik, Suvamoy; Punia, Milap; Yu, Hanchen; Chakraborty, Saurav	Is dense or sprawl growth more prone to heat-related health risks? Spatial regression-based study in Delhi, India
2019	Raitano, M.	Rain(e)scape. The presence of water as order and figure. The case study of stagni di Levante in Ostia
2012	Ren, C.; Spit, T.; Lenzholzer, S.; Yim, H.L.S.; van Hove, B.H.; Chen, L.; Kupski, S.; Burghardt, R.; Katzschner, L.	Urban Climate Map System for Dutch spatial planning

Table B.1 continued from previous page

2016	Resch, E.; Bohne, R.A.; Kvamsdal, T.; Lohne, J.	Impact of Urban Density and Building Height on Energy Use in Cities
2022	Ricart, S.; Berizzi, C.; Saurí, D.; Terlicher, G.N.	The Social, Political, and Environmental Dimensions in Designing Urban Public Space from a Water Management Perspective: Testing European Experiences
2021	Rosenberger, Lea; Leandro, Jorge; Pauleit, Stephan; Erlwein, Sabrina	Sustainable stormwater management under the impact of climate change and urban densification
2017	Rößler, S.	Demands, Opportunities and Constraints of Green Space Development for Future Urban Development under Demographic and Climate Change
2022	Salonen, T.; Hollands, J.; Sesto, E.; Korjenic, A.	Thermal Effects of Vertical Greening in Summer: An Investigation on Evapotranspiration and Shading of Façade Greening in Vienna
2021	Salvati, A.; Coch, H.	Urban climate and building energy performance in compact cities in Mediterranean climate
2022	Segura, R.; Krayenhoff, E.S.; Martilli, A.; Badia, A.; Estruch, C.; Ventura, S.; Villalba, G.	How do street trees affect urban temperatures and radiation exchange? Observations and numerical evaluation in a highly compact city
2020	Simperler, L.; Himmelbauer, P.; Ertl, T.; Stoeglehner, G.	Prioritization of stormwater management sites in urban areas
2016	Skelhorn, C.P.; Levermore, G.; Lindley, S.J.	Impacts on cooling energy consumption due to the UHI and vegetation changes in Manchester, UK
2017	Skougaard Kaspersen, P.; Høegh Ravn, N.; Arnbjerg-Nielsen, K.; Madsen, H.; Drews, M.	Comparison of the impacts of urban development and climate change on exposing European cities to pluvial flooding
2011	Steeneveld, G. J.; Koopmans, S.; Heusinkveld, B. G.; van Hove, L. W. A.; Holtslag, A. a. M.	Quantifying urban heat island effects and human comfort for cities of variable size and urban morphology in the Netherlands

Table B.1 continued from previous page

2016	Stevenson, Mark; Thompson, Jason; de Sá, Thiago Hérick; Ewing, Reid; Mohan, Dinesh; McClure, Rod; Roberts Ian; Tiwari, Geetam; Giles-Corti, Billie; Sun, Xiaoduan; Wallace, Mark; Woodcock, James	Land use, transport, and population health: estimating the health benefits of compact cities
2010	Stone, B.; Hess, J. J.; Frumkin, H.	Urban Form and Extreme Heat Events: Are Sprawling Cities More Vulnerable to Climate Change Than Compact Cities?
2016	Sun, N.; Yearsley, J.; Baptiste, M.; Cao, Q.; Lettenmaier, D.P.; Nijssen, B.	A spatially distributed model for assessment of the effects of changing land use and climate on urban stream quality
2023	Thaweepworadej, P.; Evans, K. L.	Urbanisation of a growing tropical mega-city during the 21st century — Landscape transformation and vegetation dynamics
2022	Thodesen, B.; Time, B.; Kvande, T.	Sustainable Urban Drainage Systems: Themes of Public Perception —A Case Study
2021	Vega, Kevin A.; Küffer, Christoph	Promoting wildflower biodiversity in dense and green cities: The important role of small vegetation patches
2023	Venter, Zander S.; Figari Helene; Krange, Olve; Gundersen, Vegard	Environmental justice in a very green city: Spatial inequality in exposure to urban nature, air pollution and heat in Oslo, Norway
2019	Vich, Guillem; Marquet, Oriol; Miralles-Guasch, Carme	Green streetscape and walking: Exploring active mobility patterns in dense and compact cities
2020	Visser, Philip W.; Henk, Kooi; Bense, Victor; Emiel, Boerma	Impacts of progressive urban expansion on subsurface temperatures in the city of Amsterdam (The Netherlands)
2021	Wang, Pengcheng; Liu, Zhongbing; Zhang, Ling	Sustainability of compact cities: A review of Inter-Building Effect on building energy and solar energy use
2021	Wang, XL; Wang, S; Wang, L; Fan, F	Has ridesourcing reduced haze? An analysis using the Didi app
2021	Wright, J.; Lytle, J.; Santillo, D.; Marcos, L.; Mai, K.V.	Addressing the water–energy–food nexus through enhanced green roof performance
2013	Yamagata, Y.; Seya, H.	Simulating a future smart city: An integrated land use-energy model
2023	Zhang, Z.; Sato, Y.; Dai, J.; Chui, H.K.; Daigger, G.; Van Loosdrecht, M.C.M.; Chen, G.	Flushing Toilets and Cooling Spaces with Seawater Improve Water-Energy Securities and Achieve Carbon Mitigations in Coastal Cities

B.5. Concept-centric data set: Knowledge Base

Supplementary information:

- excel file Workbook AppendixB.5.1 for stated impacts
- excel file Workbook Appendix B.5.2. for reasoned impacts

B.6. Codebook

Category	Subcodes	examples/comments
	Social Impacts	
Health (SI1)	actual health	
	health of family, personal loss	
	well-being, mental health	
	perceived health	
	nutrition	
	feelings positive or negative leading to interest groups	
	uncertainty	
	aspirations for the future	
	experience of stigmatisation	strong relation to social differentiation
	annoyance	
	dissatisfaction	
	experience of moral outrage	
	autonomy	
livability (SI2)	perception of crime and safety	
	perceived quality	
	actual quality	
	disruption daily living practice	
	leisure & recreation	
	aesthetic quality	
	environmental amenity value	
	physical quality of housing	
	homeliness, social quality	
	availability of housing facilities	
	adequacy of physical infrastructure	
	adequacy of social infrastructure	
	actual crime and safety	
economic impacts (SI3)	workload	
	standard of living/affluence	
	access to public goods/services	
	access to government and/or social services	
	economic prosperity/resilience	CC as future scenario always affects this
	income	
	property values	
	occupational status	
	level of unemployment in the community	
	loss of employment options	
	replacement costs of environmental functions	
	economic dependency or vulnerability	
	disruption of local economy	
	burden of national debt	
indicative cultural impacts (SI4)	change in cultural values	
	cultural affrontage	
	cultural integrity	
	cultural marginalisation	
	profanisation of culture	
	loss local language or dialect	
	loss natural/cultural heritage	
family and community impacts (SI5)	alterations family structure	
	sexual relations change	
	obligations to living elders	
	family violence	
	disruption of social networks	
	changed demographic structure of the community	
	community identification and connection	
	perceived and actual community cohesion	
	social differentiation and inequity	
	social tension and violence	
institutional, legal, political and equity impacts (SI6)	workload and viability of government or formal agencies	
	workload and viability of non-government agencies and informal agencies including community organisations	
	integrity of government and government agencies	
	loss of tenure or legal rights	
	loss of subsidiarity	
	violation of human rights	
	participation in decision making	

	access to legal procedures and to legal advice	
	impact equity (notions about fairness in the distribution of impacts across the community	
gender relations (SI7)	women's physical integrity	
	personal autonomy of women	
	gendered division of production-oriented labour	
	gendered division of household labour	
	gendered division of reproductive labour	
	gender-based control over, and access to, resources and services	
	equity of educational achievement between girls and boys	
	political emancipation of women	
Transitions		
Densification contextual information		
Densification	densification attraction	
	densification cost	
	densification enabler	
	densification strategies	
	strategy dependency	
	accompanying policies/tools	
CA		
CA	**Category**	**Code**
Energy transition	**Production**	Energy resources & generation
		emerging technologies
	Use	mobility
		heating/cooling
	Energy infrastructure	grid(distribution)
		storage
Climate Change Adaptation	**Management**	risk plans
		policies
		social infrastructure + education
	Thermal comfort	UHIE
		outdoor temperature
		indoor temperature
		shading
		solar radiation
		ventilation
		air corridors
		evapotranspiration
	Water	fluvial flood
		dykes/grachten
		irrigation
		potable
		rainwater collection
		drainage

Deductive Codes								
scale (10)	**Amsterdam**	**Other**	**biodiversity**	**Circular economy**	**Region/country (55)**	**Countries (31)**	**Field (31)**	**method (41)**
block-scale	AMS_geography	energy expenses	green space	CE emissions	**Case Region (16)**	**Case Countries (9)**	architecture	air flow modelling
building-scale	AMS_policies	needs vulnerable at home	underground	CE mobility	Austria	Austria	Atmospheric science	building energy system model
canopy-scale	AMS_public budget	adaptability	pollution	CE costs	Case Region	Denmark	biology	carbon footprint model
city-scale		human behaviour			Central Europe	Finland	civil engineering	case study evaluation
district-scale		cycling			Denmark	Germany	Climate science	climate scenarios
metropolitan area scale		walking			Europe	Ireland	Economics	correlation analysis
neighbourhood-scale		climate justice			Finland	Norway	electrical engineering	disease distribution mapping
peri-urban areas		gentrification			Germany	Switzerland	energy policy	energy consumption survey
region-scale		emerging technology			global	The Netherlands	energy science	energy demand modelling
village-scale		future research			Ireland	The UK	environmental engineering	energy system modelling
		gender			no region	**Other (22)**	environmental science	field measurements
		intersectional			Northern Europe	Australia	Geo-ecology	framework definition
		knowledge, silos			Norway	Brazil	geo-sciences	flood modelling
		location			Switzerland	Canada	Geography	green space - property value modelling
		lock-in			The Netherlands	Chile	geology	green space visitor survey
		multifunctionality			The UK	China	Geophysics	health spatial distribution model
		needs for densification			Western Europe	France	hydrology	human comfort spatial models
		ownership			**Other (39)**	india	landscape planning	hydrogeologcial modelling
		planning bias			Australia	Iran	Marine-Earth Science and Technology	interviews
		poverty			Australia and New Zealand	Israel	meteorology	land use simulations
		space competition			Brazil	Italy	Physics	literature review
		spill-over			Canada	Japan	regional development	living lab
		urban inequality			Central Asia	New Zealand	Sewage Engineering	machine learning
		urban planning			Central North America	Nigeria	transportation engineering	microclimate model
		trees			Central South America	Poland	Urban Design	microclimatic scenarios
		green space			Chile	Portugal	Urban Development	multi-case study
					China	Reunion	Urban economics	planning scenarios
					East Asia	Singapore	Urban Engineering	pluvial flooding simulations
					Eastern Australia	South Africa	Urban Sociology	pollution modelling
					Eastern North America	South Korea	water and environmental biotechnology	Research by Design
					Eastern South America	Spain	Water science	resident interviews
					Hong Kong	USA		resident survey
					india	Vietnam		road network modelling
					indian ocean			simulation
					Israel			spatial data analysis
					Italy			temperature model
					Japan			transport GPS data analysis
					mediterranean			transport modelling
					New Zealand			urban form models
					Nigeria			vegetation survey
					North America			water system model
					Poland			
					Portugal			
					Reunion			
					Saudi-Arabia			
					Singapore			
					South Africa			
					South Korea			
					Southeast Asia			
					Southern Africa			
					Spain			
					Sub-tropical coastal cities			
					USA			
					Vietnam			
					Western Australia			
					Western North America			
					Western Sub-saharan Africa			

Appendix C

Interviews

C.1. Form of informed consent (ICF)

Delft University of Technology
HUMAN RESEARCH ETHICS
INFORMED CONSENT

Participant Information – Date: XX-XX-XXXX

You are being invited to participate in a research study titled

System interdependencies in the pursuit of sustainable urban development – identifying social trade-offs of urban densification and urban transition goals.

This study is being conducted by Laila Fiedler as corresponding researcher (l.l.fiedler@student.tudelft.nl) and student at TU Delft, as a Master thesis project of the MSc programme Industrial Ecology (TU Delft – Leiden University joint programme). First supervisor and responsible for the student's research activities is Trivik Verma (t.verma@tudelft.nl) at the Faculty of Technology, Policy and Management at TU Delft. Second supervisor is Nazli Aydin (n.y.aydin@tudelft.nl) at the Faculty of Technology, Policy and Management at TU Delft.

Summary of the purpose of this research study:
The purpose of this research study is to build a knowledge base of urban densification interventions and their social impacts. Direct and indirect social impacts or "trade-offs" on the social dimension will be included. In the focus are impacts that arise from a relationship between densification and other urban transition ambitions, such as the energy transition, climate change adaptation, circular economy or increase of biodiversity.
This study includes a literature review of academic work published on these relationships. A series of interviews, including the one that you are going to participate in, intends to enrich this knowledge base with experience from the field. By providing your insight to the question of how urban densification and other transitions affect the social dimension, the knowledge base can be evaluated for the Dutch municipal context.
You will be asked questions on your professional experience with social impacts of urban densification or other urban transitions, or social impacts resulting from the interplay of densification and other urban transitions.

Form of the data collection:
For the purpose of this research, you are kindly invited to participate in an interview, which will take approximately 60 minutes to complete. After the completion and transcription of the interview, but before the publication of the thesis, you will be sent a summary of the interview in a follow-up email. This summary includes the interview content (conclusions, paraphrased sections and potential quotes) that the researcher wants to include in the thesis text. This content will only be published with your confirmation and agreement to the publication after reception of the summary.

Use of the data:
The data will be used for

- The graduation project in the form of the thesis titled *System interdependencies in the pursuit of sustainable urban development – identifying social trade-offs of urban densification and urban transition goals*
- The publication of this thesis

Thereby the information included in the public version of the thesis might be used as a foundation for future research, publications, reports, future policymaking or mentioned in teaching.

Potential risks of the participation and mitigation measures:
Risks:
After the publication of the thesis, the agreed to sections of the interviews will be publicly accessible. Even though the participants' names will not be published, a risk of re-identification exists due to the participants' role within the municipality or their job description. If a statement is traced back to a participant through re-identification, several risks arise:

1) Stigmatization, loss of reputation or other social long-term risk due to information given in the agreed to sections of the interview,
2) Financial repercussions, loss of livelihood/employment or other financial long-term risks due to information given in the agreed to sections of the interview.

This research will make use of online conversations (e-mails, interviews) and an online data storage environment (TU Delft MS Onedrive storage). As with any online activity the risk of a breach is always possible. To the best of the researcher's ability your answers in this study will remain confidential.
However, potential risks of breach entail

1) the breach of personally identifiable information contained in e-mail conversations, the list of participants including contact addresses, names and job descriptions/positions, as well as the information given in this informed consent form,
2) the breach of the personally identifiable research data given in the course of the interview, its recordings, transcripts or summary.

As a consequence of such breaches, several potential risks arise:

1) publication or extortion of any personally identifiable information (including the signature at the end of this form) or personally identifiable research data given in the e-mail correspondence or in the interview,
2) other forms of unethical or criminal behaviour making use of any personally identifiable information (including the signature at the end of this form) or personally identifiable research data given in the e-mail correspondence or in the interview,
3) stigmatization, loss of reputation or other social long-term risk due to information given in the e-mail correspondence or in the interview,
4) financial repercussions, loss of livelihood/employment or other financial long-term risk due to information given in the e-mail correspondence or in the interview.

Mitigation Measures:
We will minimize the risks by

1) asking you to only give information during the interview which relates to the purpose of the research and that you want to share voluntarily,
2) storage of personally identifiable information or personally identifiable research data only in TU Delft environments (TU Delft MS Outlook, TU Delft MS Teams, TU Delft Onedrive, all login-secured),
3) not sharing the non-anonymous information outside the research team (student, 1st and 2nd supervisor) involved in this research project,
4) not accessing this information from public internet network connections (i.e. no access through open, public wifi services),
5) deletion of any data which is not directly applicable for the purpose or conduction of this research,
6) not including your name in the published thesis text,
7) asking you for agreement to the publication of the interview sections that are intended to be published within the thesis text,
8) not publishing any summary, transcript or recording of the interview as supplementary information to this thesis,
9) deletion of the data collected during this research latest after 2 years of termination of this project.

Voluntary character of the participation:
Your participation in this study is entirely voluntary and you can withdraw at any time. You are free to omit any questions. If you should decide to revoke your participation in this research at a later point, including after the conduction of the interview, any data already provided by you will be deleted from the storage environment.

Contacts:
In case you want to request any further information, revoke your participation, request the deletion of data or have any other remark please contact.

Laila Fiedler –
corresponding researcher of this MSc thesis project
MSc student at the TPM faculty of TU Delft: l.l.fiedler@student.tudelft.nl

Trivik Verma –
responsible researcher, 1st supervisor to this MSc thesis project,
assistant professor at the TPM faculty of TU Delft: t.verma@tudelft.nl

Nazli Aydin
– 2nd supervisor to this MSc thesis project,
assistant professor at the TPM faculty of TU Delft: n.y.aydin@tudelft.nl

<table>
<tr><th>PLEASE TICK THE APPROPRIATE BOXES</th><th>Yes</th><th>No</th></tr>
<tr><td>A: GENERAL AGREEMENT – RESEARCH GOALS, PARTICPANT TASKS AND VOLUNTARY PARTICIPATION</td><td></td><td></td></tr>
<tr><td>1. I have read and understood the study information dated as above, pg. 1, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.</td><td>☐</td><td>☐</td></tr>
<tr><td>2. I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and that I can withdraw from the study at any time, without having to give a reason.</td><td>☐</td><td>☐</td></tr>
<tr><td>3. I understand that taking part in the study involves:
- e-mail correspondence
- interview participation, audio- and video-recorded, accompanied by written notes for transcription
- the information given in this informed consent form</td><td>☐</td><td>☐</td></tr>
<tr><td>4. I understand that there is no monetary compensation for my participation in this study</td><td>☐</td><td>☐</td></tr>
<tr><td>5. I understand that the study will end on 30-11-2023.</td><td>☐</td><td>☐</td></tr>
<tr><td>B: POTENTIAL RISKS OF PARTICIPATING (INCLUDING DATA PROTECTION)</td><td></td><td></td></tr>
<tr><td>6. I understand that taking part in the study involves collecting specific personally identifiable information (PII) and associated personally identifiable research data (PIRD) with the potential risk of my identity being revealed.
a) PII: my name, e-mail-address, signature (at the bottom of this consent form), job description/position, professional experience
b) PIRD: recording and transcript catching the professional evaluation of the process and impacts of urban densification and other urban transitions
c) Risks:
• due to the small and specialised sample of participants there is a risk of re-identification amounting to consequent risks, such as:
i. Loss of public, private or professional reputation or stigmatisation or other social long-term risks
ii. Financial repercussions, loss of employment/livelihood or other financial long-term risks
• and due to the online processing of the provided data there is the risk of data breach, amounting to the potential consequent risks:
i. unethical or criminal use of my PII</td><td>☐</td><td>☐</td></tr>
<tr><td>7. I understand that the following steps will be taken to minimise the threat of a data breach, and protect my identity in the event of such a breach:

a) Secure data storage with access limited to the research team
b) Provision of interview sections intended to be published upfront for approval
c) Access of the data only within private internet networks and the educational wireless internet connection eduroam
d) Notification to me of the event of a breach and how much of my personal data is affected</td><td>☐</td><td>☐</td></tr>
<tr><td>8. I understand that personal information collected about me that can identify me, such as my name, e-mail address, signature (provided by me in this consent form), job position, will not be shared beyond the study team.</td><td>☐</td><td>☐</td></tr>
</table>

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
9. I understand that the (identifiable) personal data I provide will be destroyed at the latest 2 years after termination of the research.	☐	☐
C: RESEARCH PUBLICATION, DISSEMINATION AND APPLICATION		
10. I understand that after the research study the information I provide as in the agreed upon interview summaries will be used for		
a) The MSc thesis text publication, including i. Quotes without my name after my approval, ii. Paraphrased interview sections without my name after my approval, iii. Meta-conclusions from the interview	☐	☐
b) The result of the MSc thesis, the established knowledge database, which will be made available for future research, academic publication, reports, policy-development or decision-making.	☐	☐
11. I agree that my responses, views or other input can be quoted anonymously in research outputs.	☐	☐
D: (LONGTERM) DATA STORAGE, ACCESS AND REUSE		
12. I give permission that my evaluations, as agreed upon in the interview summaries or in e-mail correspondence, which will be included in the thesis result, such as the social impacts of urban densification and other urban transitions, to be archived in TU Delft education repository so that they can be used for future research and learning.	☐	☐
13. I understand that access to this repository is open.	☐	☐

Signatures

_________________________ _________________________ ________
Name of participant [printed] Signature Date

I, as researcher, have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

Laila Fiedler ________________ __________________ ________
Researcher name Signature Date

Study contact details for further information:

Laila Fiedler –
corresponding researcher of this MSc thesis project
MSc student at the TPM faculty of TU Delft: l.l.fiedler@student.tudelft.nl

Trivik Verma –
responsible researcher, 1st supervisor to this MSc thesis project,
assistant professor at the TPM faculty of TU Delft: t.verma@tudelft.nl

Nazli Aydin
– 2nd supervisor to this MSc thesis project,
assistant professor at the TPM faculty of TU Delft: n.y.aydin@tudelft.nl

C.2. Interview protocol

Interview Checklist per participant
1st contact: explanation what, who i am, what the idea and expected timeline is
Follow-up on 1st contact
Confirmation of participation?
date & link for participation
send ICF
send questions prior to interview
reminder for interview necessary?
received ICF prior to interview?
setup interview location & notepad
check probing questions for specific person
record
conduct interview
check recording length, sound and transcript
write memo
transcript correction
follow-up on follow-up labels
make summary (check follow-up labels clarification, discussion labels)
ask for permission of use
agreement with sections
my signature in consent form
follow-up reminder sent
thank and say that link to thesis will be sent after publication
coding
theme extraction
result analysis
expiration date set to
send thesis/framework

C.3. Interview information and questions to participants

MSc Study Programme Industrial Ecology

INDUSTRIAL ECOLOGY INNOVATIVE BY NATURE

PREPARATORY INFORMATION AND INTERVIEW QUESTIONS (Status: XX-XX-XXXX)

You receive this information because you have agreed to participate in an interview for the MSc thesis of Laila Fiedler in the field of Industrial Ecology at Leiden University and Delft University of Technology, titled:

System interdependencies in the pursuit of sustainable urban development – identifying social trade-offs of urban densification and urban transition goals.

The information below is divided into

I) General information – Where, who and when?
II) Informed consent form
III) Introduction to the aim of the thesis project
IV) interview questions guide

I. GENERAL INFORMATION – WHEN, WHERE AND WHO?

When: XXXXX

Where: inert link XXX

Who: Interviewer & corresponding researcher, Laila Fiedler, l.l.fiedler@student.tudelft.nl

II. INFORMED CONSENT FORM

The interview will be conducted after receiving the consent form, sent out on XX-XX-XXXX. I would kindly ask you to return a signed copy of the form to me via email before the interview. The form and any follow-up questions can be sent to l.l.fiedler@student.tudelft.nl

III. INTRODUCTION TO THE AIM OF THE THESIS PROJECT

As urban densification to prevent sprawl and counter the housing shortage runs parallel with the goals and transitions of the energy transition, climate change adaptation, a circular economy and the increase of biodiversity, many societal challenges arise. How interventions to achieve these transitions interact and impact the societal dimension is the focus of this work.

In my thesis, I am developing a framework about the social impacts arising from the interaction between urban densification interventions and four urban transitions. These are namely, 1) the energy transition, 2) climate change adaptation, 3) biodiversity increase and 4) the establishment of a circular economy. This is exemplary displayed in figure a and figure b below.

1/6

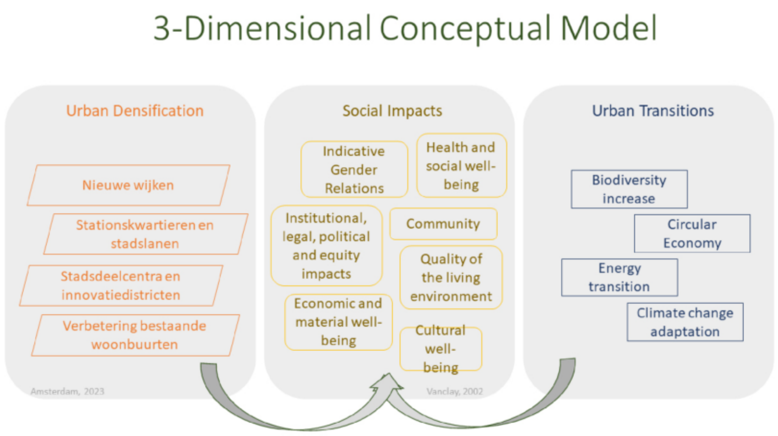


Figure a: Elements of the 3D conceptual model: Densification strategies, urban transitions and social impacts arising from the interaction of the two other dimensions.

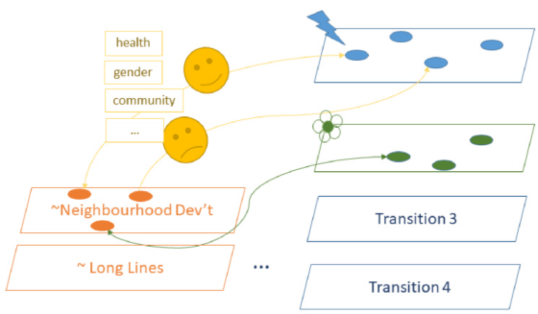


Figure b: Imaginary example of interaction between elements of the densification interventions and the transition leading to potential social impacts.

By participating in the interview, you help to inform research on urban densification strategies. Especially the understanding of urban densification in the context of Dutch spatial planning and the specific case of the municipality of Amsterdam.

Thank you for your participation!

IV. INTERVIEW QUESTIONS GUIDE

A. Formalities (yes/no, <5 mins)

1. Are you aware of and in agreement with the video and audio recording of this interview and the use of the information collected during this interview as indicated in the consent form? Please indicate by replying with "yes" or "no".

2. Open (procedural) questions have been answered by the corresponding researcher before the commencement of the interview. Please indicate by replying with "yes" or "no". *(If your answer is no, please feel free to ask them now.)*

B. General (brief answers, <5 mins)

3. Could you shortly explain what your occupation and professional position entail?

4. What is your knowledge of and interest in the concept of urban densification? Could you give an example of densification measures you have encountered?

5. What do you think about the role that densification of the built environment is playing in the city of Amsterdam's development strategies?

C. Densification and urban transitions (< 30 mins)

Your professional experience might be located more in one of the following topic sections, less in another. However, you can indicate for the other sections whether you would like to add a statement before we move to the next section.

Energy transition

6. How do you think densification interventions might affect the production and use of energy in the city in the pursuit of the energy transition?

7. In terms of urban energy infrastructure, where do you see that it is impacted by densification processes?

8. Looking at the social impact categories as shown in figure a, do you think such impacts will be created in the interplay of the energy transition and urban densification? Why or why not? If yes, how?

   You can consult this list:
   - community cohesion,
   - gender implications,
   - economic well-being,
   - institutional, legal, political and equity impacts,
   - human health and well-being,
   - livability, the quality of the living environment,
   - cultural well-being

Climate Change Adaptation

9. How do you evaluate the relationship between urban densification and climate change adaptation in the built environment?

10. Which interactions between adaptation and densification might affect residents and the environment inside the city and the metropolitan region?

11. Looking at the social impact categories as shown in figure a, do you think such impacts will be created in the interplay of climate change adaptation and urban densification? Why or why not? If yes, how?

    You can consult this list:
    - community cohesion,
    - gender implications,
    - economic well-being,
    - institutional, legal, political and equity impacts,
    - human health and well-being,
    - livability, the quality of the living environment,
    - cultural well-being

Urban Biodiversity

12. How do urban densification measures affect biodiversity above and below ground?

13. Looking at the city scale, how do you think densification interventions in one area affect biodiversity and residents in
    - surrounding neighbourhoods,
    - the Amsterdam Metropolitan Region?

14. Looking at the social impact categories as shown in figure a, do you think such impacts will be created in the interplay of pursuits of an increase of urban biodiversity and urban densification? Why or why not? If yes, how?

    You can consult this list:
    - community cohesion,
    - gender implications,
    - economic well-being,
    - institutional, legal, political and equity impacts,
    - human health and well-being,
    - livability, the quality of the living environment,
    - cultural well-being

Urban Circular Economy

15. How do you estimate the impact of densification on material and immaterial flows through society?

16. What effects might urban densification have on the uptake of a circular economy?

17. Looking at the social impact categories as shown in figure a, do you think such impacts will be created in the interplay of the uptake of a circular economy and urban densification? Why or why not? If yes, how?

    You can consult this list:
    - community cohesion,
    - gender implications,
    - economic well-being,
    - institutional, legal, political and equity impacts,
    - human health and well-being,
    - livability, the quality of the living environment,
    - cultural well-being

D. Future developments & scenarios (10 mins)

In this section I would like you to reflect on what we have talked about so far and to use these ideas to think ahead…

18. Reflecting on the above, which measures or policies should/need to accompany densification to foster socially sustainable urban development?

19. Do you think urban densification can support social equity as part of social sustainable development in the city? If yes, why, and if no, why not?

20. If you – briefly - think about future scenarios, how do you think the issues that we just talked about may be affected by or change due to
    - potential societal paradigm shifts (e.g. de- or green growth scenarios),
    - future emerging technologies?

E. Closing (< 5 mins)

21. What other challenges or benefits do you see in connection with urban densification that we have not yet touched upon?

22. Is there anyone that you would recommend me to get in contact with?

23. How should I describe your position for the (public) use of sections of this interview?

Thank you for your time, cooperation and willingness to participate in the interview! The collected information will be shared with you in the form of a summary of the interview transcript, paraphrased sections and quotes that might find entrance into the thesis (see also section C of the informed consent form).

Please do not hesitate to contact me for any further information, follow-up or exchange of ideas!

C.4. Interview summaries

Supplementary information:

- Appendix C.4-Summaries-interviews

C.4.1. Participant D

C.4.2. Participant E

C.4.3. Participant F

C.4.4. Participant G

C.4.5. Participant H

C.4.6. Participant I

C.4.7. Participant J

C.4.8. Participant K

C.4.9. Participant L

Appendix D

AMS-region results and Amsterdam densification locations

D.1. Ams-region results on individual social impact level

Table D.1: Prevalent individual social impacts per theme stated in the literature review, reduced to the AMS-region (ranked by frequency). The total stated number of quotations in this theme is given in the top row.

electricity and energy sources and grid 14 quotations	**heating and cooling 26 quotations**	**mobility 26 quotations**	**UHIE, heat, drought Top 52 of 75 quotations**	**WATER, flood and rain 18 quotations**
energy expenses (4)	well being (5)	leisure & recreation (5)	well being (14)	physical infrastructure (4)
econ dependency & vulnerability (2)	energy expenses (4)	social differentiation (3)	actual health (8)	actual health (2)
physical infrastructure (2)	actual health (2)	access public services (2)	environmental amenty value (8)	actual quality (2)
cultural values (1)	housing quality (2)	employment options (2)	physical infrastructure (8)	environmental amenty value (2)
econ prosperity & resilience (1)	social differentiation (2)	living standard (2)	energy expenses (6)	actual safety (1)

Table D.1 continued from previous page

living standard (1)	actual quality (1)	well-being (2)	actual quality (5)	econ prosperity & resilience (1)
perceived health (1)	autonomy (1)	actual health (1)	social differentiation (3)	leisure & recreation (1)
social differentiation (1)	cultural values (1)	actual quality (1)		participation decisionmaking (1)
well being (1)	econ dependency & vulnerability (1)	cultural values (1)		replacement environmental functions (1)
	income (1)	environmental amenty value (1)		social infrastructure (1)
	living standard (1)	family health, loss (1)		social network disruption (1)
	perceived health (1)	perceived health (1)		well-being (1)
	physical infrastructure (2)	routine disruption (1)		
	routine disruption (1)	social infrastructure (1)		
		social network (disruption) (1)		
		social quality (1)		

Table D.2: Prevalent individual social impacts per theme reasoned from the literature review, reduced to the AMS-region (ranked by frequency). The total stated number of quotations in this theme is given in the top row.

electricity and energy sources and grid -no quotations-	**heating and cooling Top 28 of 43 quotations**	**mobility 25 quotations**	**UHIE, heat, drought Top 39 of 51 quotations**	**WATER, flood and rain 10 quotations**
	actual health (6)	autonomy (3)	well-being (10)	actual health (2)
	living standard (5)	actual health (3)	actual-health (9)	environmental amenty value (2)
	social differentiation (5)	social differentiation (3)	social differentiation (4)	actual quality (1)

Table D.2 continued from previous page

	well-being (5)	access government services (2)	social quality (4)	actual safety (1)
	social quality (4)	leisure & recreation (2)	living standard (3)	government workload viability (1)
	autonomy (3)	routine disruption (2)	perception quality (3)	local economic disruption (1)
		access public services (1)	actual quality (2)	property value (1)
		aesthetic quality (1)	aesthetic quality (2)	well-being (1)
		cultural values (1)	econ dependency & vulnerability (2)	
		gendered resource access (1)		
		government integrity (1)		
		income (1)		
		living standard (1)		
		perceived health (1)		
		physical infrastructure (1)		
		replacement environmental functions (1)		

D.2. The densification variants locations in Amsterdam mapped

Higher quality resolution of the images can be viewed at: https://www.amsterdam.nl/wonen-leefomgeving/ontwikkelstrategie-2035/

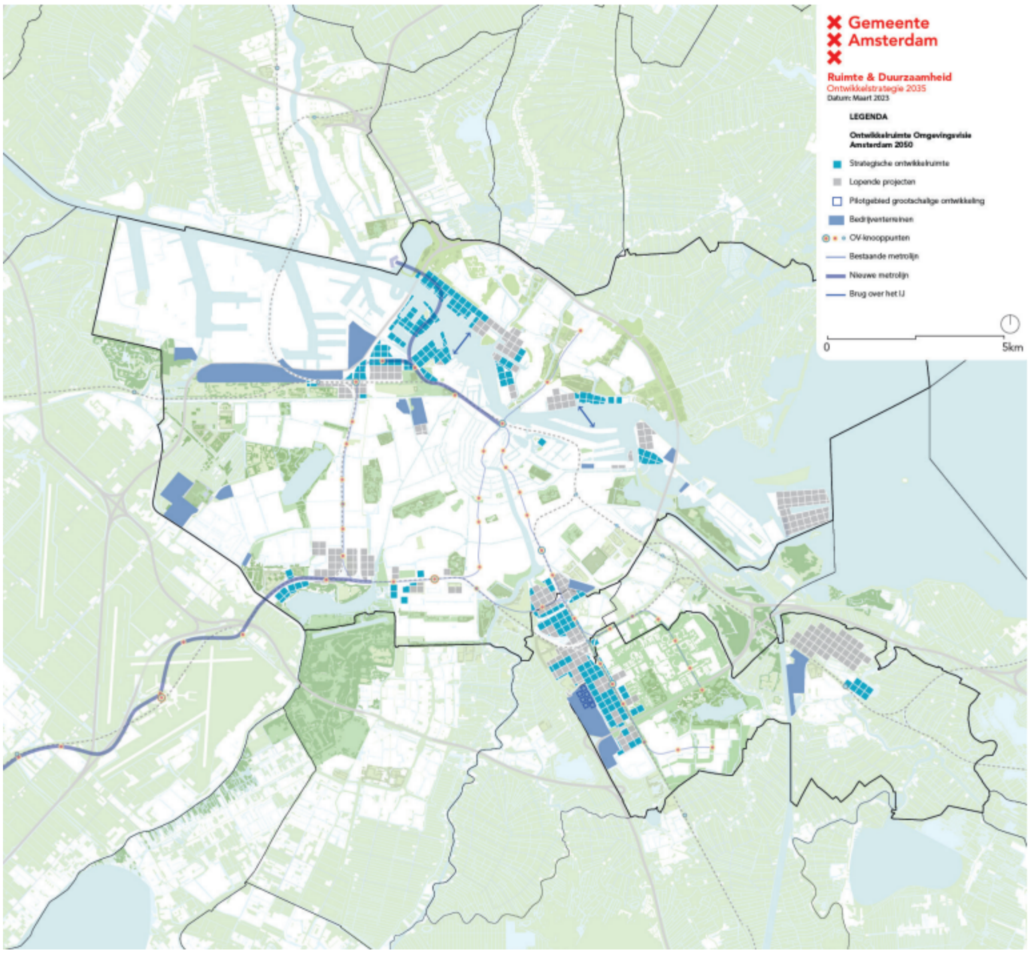


Figure D.1: The New Neighbourhoods variant in the densification strategy of Amsterdam, March 2023 (Gemeente Amsterdam, 2023k).

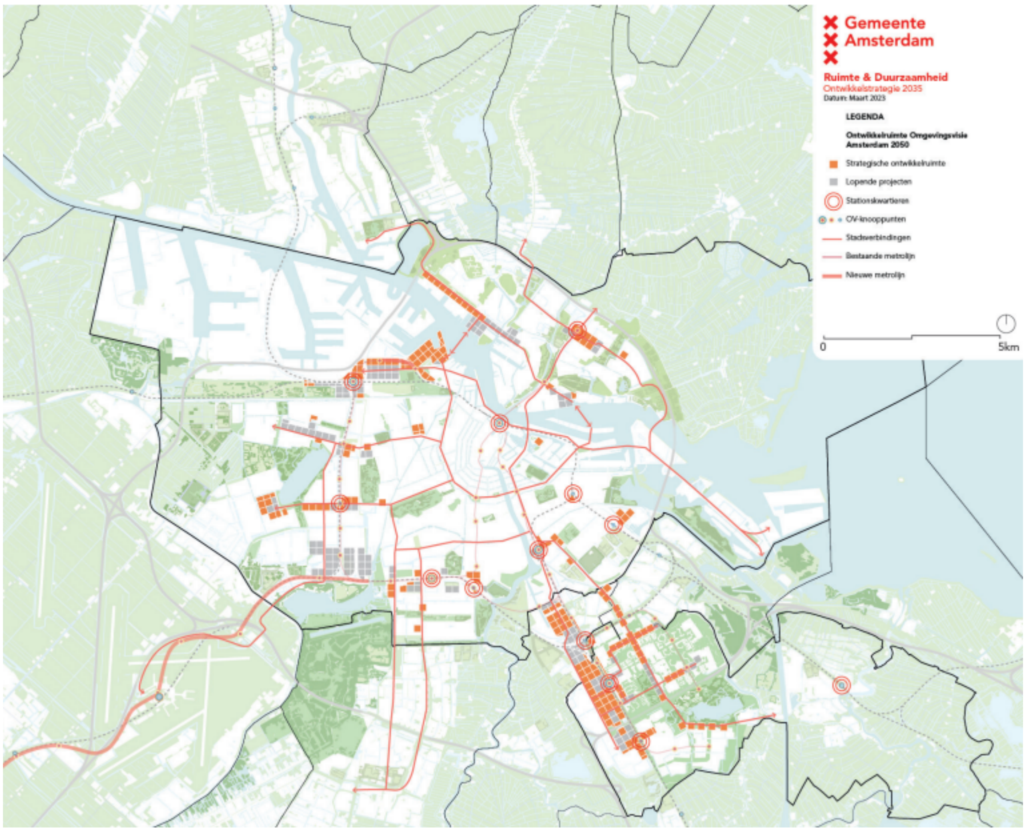


Figure D.2: The Station quaters and transport lanes variant in the densification strategy of Amsterdam, March 2023 (Gemeente Amsterdam, 2023k).

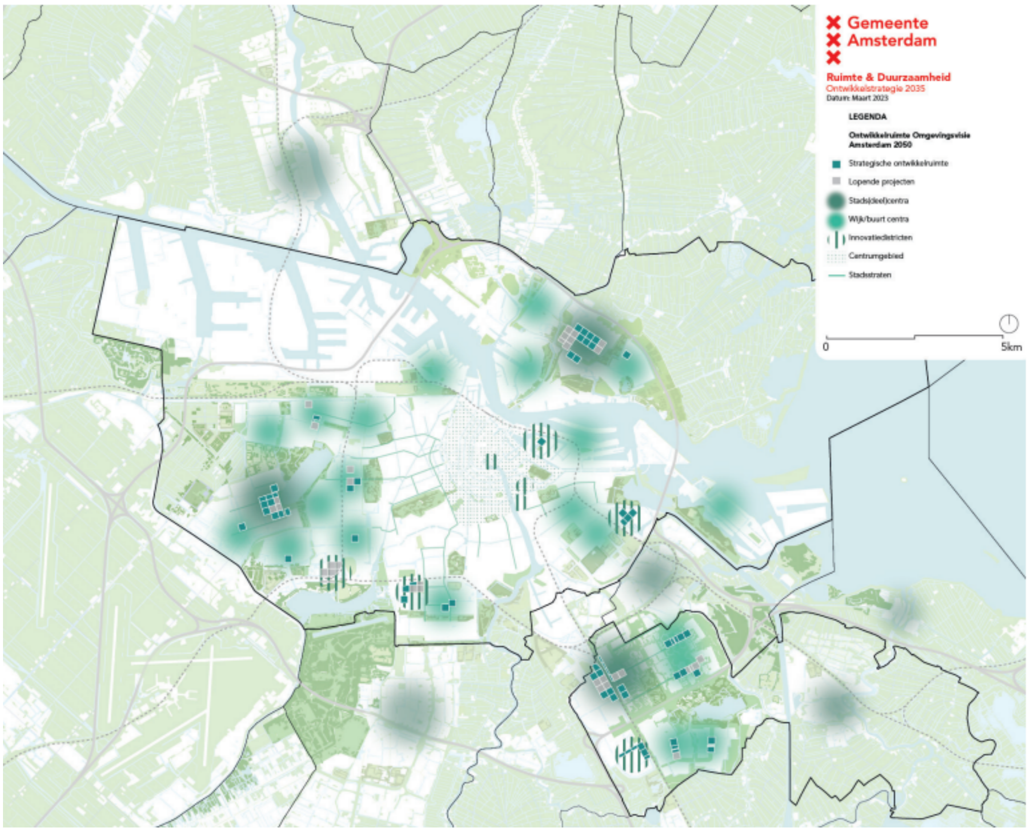


Figure D.3: The Neighbourhood centers variant in the densification strategy of Amsterdam, March 2023 (Gemeente Amsterdam, 2023k).

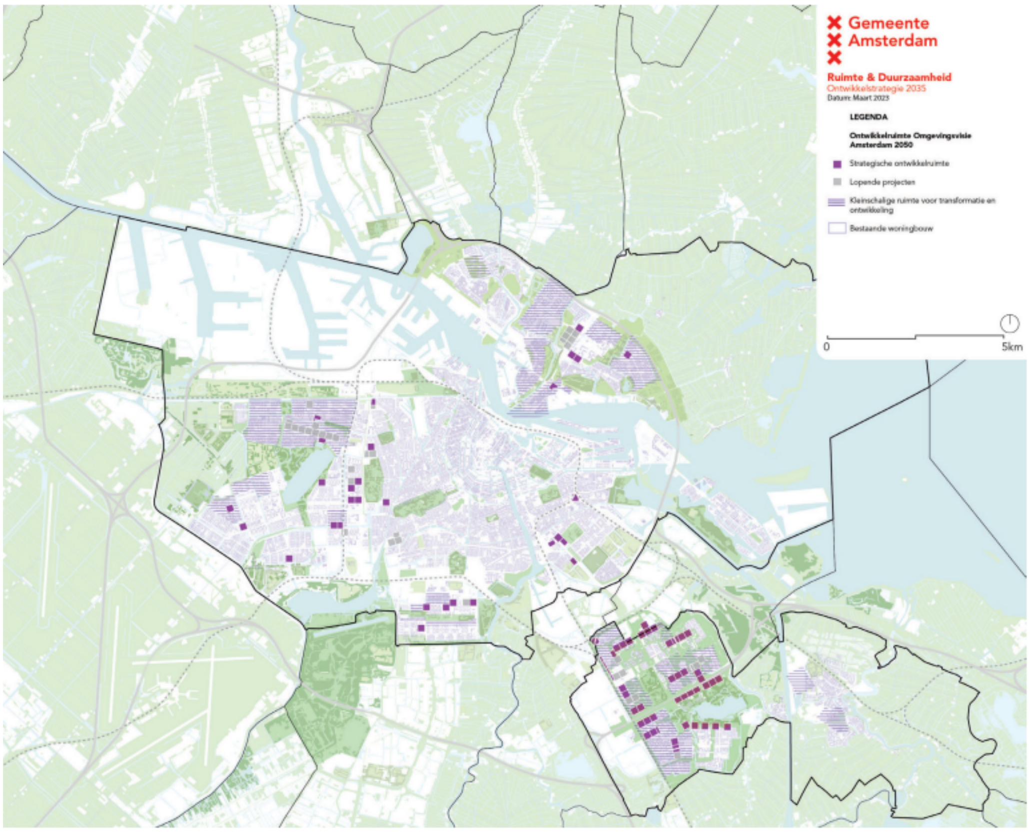


Figure D.4: The Existing Neighbourhood development variant in the densification strategy of Amsterdam, March 2023 (Gemeente Amsterdam, 2023k).

Appendix E

Quotation Examples

This appendix shows the illustrated examples from literature and the interview in the context of the five themes in full text.

E.1. The UHIE, heat, drought

Well-being and actual health in both perspectives

Venter et al. (2023, p. 5) call for the observation of existing urban inequalities in densification developments. Access to green space and exposure to air pollution and solar radiation in their case study Oslo are correlating with income groups. Densification not accounting for these inequalities may increase adverse CC consequences and should therefore be part of CCA risk plans.

Densification impacts urban temperatures, the actual quality of the built environment and housing structures and thereby, well-being and health.

As Brom et al. (2023, p. 12) stated,

> "the most built-up areas (city center and informal settlements) were the hottest and were negatively scored by the heat-map against the mean."

Nonetheless, amongst the literature data set there were also indications of densification having the ability to lower the UHIE. For instance Kang et al. (2022, p. 13) found that

> "[i]n terms of city size and aggregation, compact urban forms increase the urban heat island effect, but compact urban forms in terms of connectivity have resulted in alleviating the [UHIE]."

Also Gadish et al. (2023, p.12) found that increased building heights that deepen street canyons might lower the UHIE through the shading that is provided. In their study this effect was shown despite the parallel consequences of smaller wind speeds and increased mid-day air temperature. This affect they connect in particular to the sensation of heat stress by pedestrians.

A thorough discussion on the potential outcomes of intensive urban densification on outdoor temperatures and wind speeds can be found with Deng et al. (2023). Their study provides a detailed analysis on the complex relationships between building density and heights and wind speeds and diurnal and nocturnal temperatures. The authors found that even if daytime temperatures may be decreased, heat stress may still be significant due to decreased wind speeds at 10 m above ground levels (Deng et al., 2023). Additionally, Erlwein and Pauleit (2021) elaborate, that an open building arrangement, enabling air flows into the built-up block is more effective, than increasing open sky views. In combination with additional shading by increased building heights, this can lower short-wave radiation and improve the residents' thermal comfort. Barbosa et al. (2019, p. 15) add that the "standardization of volumetry" of the buildings contributes to impermeability of the urban fabric for ventilation while the model of Back et al. (2023) emphasises the observation of major wind directions.

Well-being of urban residents may benefit from densification developments if the process leads to the inclusion of small green spaces. In their study of Mediterranean cities, they highlight the positive impacts on well-being, equity and biodiversity that pocket parks, agglomeration of trees on pedestrian routes and small squares may provide to residents and ecosystems.

Byrne et al. (2016) accentuate the variability of heat stress on distinct socio-demographic groups and the needs and well-being of vulnerable groups at home. Where thermal inequity emerges, green urban development might benefit these strata. Also Belcher et al. (2019) identify green areas, in this case

vertical greenery as non-monetary ecosystem services, that manifest in monetary reduction of energy bills for cooling.
Finally, like Brom et al. (2023), Lemonsu et al. (2015) make the significant remark, that the overlap of high population density and high built up areas and UHIE intensity in urban centers increases these areas' vulnerability. Particularly nocturnal and diurnal amplitudes of the UHIE should be observed by policymakers and planners.

Heat stress was raised in connection to the competition for space by participant K. The implementation of UHIE prevention had been voluntary in new developments, despite the shading, cooling, water storage and biodiversity benefits. The participant criticises this in particular with regard to the actual and mental health impacts of plants and trees and resulting CCA (C.4.8, ID 8, ID 19). This warning was emphasised by the positive impact of green space for residents' mental health visible during the SarS-CoV-2 pandemic (C.4.8, ID 7).

Participant G visualises the complexity of densification:

> "For example, for adaptation it can be good if you have high buildings it creates a lot of shades so it's [densification is] not always a negative thing for climate adaptation, it can also have some positive effects as well. [...] But it's also more stone. Like if you have a park before within the city and you turn it into houses, it also takes away a cool place where people can go to who seek shade. [Also,] if you first you didn't have any stones, now you have stones, it is more difficult to infiltrate water and you can also create more problems." (C.4.4, ID 3).

The creation of heat problems by densification was "a big risk", seen by G, which the municipality "tr[ied] to tackle it by getting more green into the city and it's a real opposite of course from the densification that all the places that are left are taken in by new buildings." The respondent urges that it was necessary to "make sure that there's open space left to cool the city down. [...] [I]f you don't have space, take other measures, for example, green on the roofs or green facades" (C.4.4, ID 10). A warning to not create adverse impacts was issued by the same respondent at the example of the transformation of former industrial areas to residential areas: "You have to take into account whether you create other risks, especially if you are in an industrial area and there's mostly a lot of stone. If you are creating houses you need to do it without creating more risks for overheating, or drought or the other themes [of CC]" (C.4.4, ID 3). The alterations that densification infers on air corridors, ventilation and the resulting thermal quality was discussed by respondent G. Referring to Buikslotersham, a Northern Amsterdam neighbourhood which has been under development from a former harbour and industrial area to an area with a majority of residential use, G states the diverging impact of air corridors, which may be due to building orientation. In hot weather, residents might experience this as refreshing, in cold or windy conditions, residential comfort may be diminished (C.4.4, ID 11).

Physical infrastructure and environmental amenity value in literature
Giving further attention to the effect between buildings, P. Wang et al. (2021) call for more attention of researchers to the topic to keep energy performances of buildings and thermal comfort of residents in balance. On the individual building layer, Ahmadian et al. (2019) concludes the easily accessible measure of cross-ventilation for cooling.
The impact of street trees is important and was raised as one of the environmental amenity values. The cooling effect of trees and other green areas on air and surface temperature, increasing the thermal comfort of urban residents in the wake of CC (in particular pedestrians) has been widely described (Back et al., 2023; A. Oliveira et al., 2021; Ren et al., 2012; Salonen et al., 2022; Segura et al., 2022; Stone et al., 2010). Through their provision of shading and transpiring cooling, Segura et al. (2022) term street trees as "an important driver of street micro-climate [... and providing] key mechanisms for improving thermal comfort in urban areas" (Segura et al., 2022, p. 1). Reviewing works of the past ten years, the authors discuss the difficulty and variability of modelling the potential of street trees to cool urban street canyons. The trees' cooling effect depends on "the canyon geometry and sun-orientation, the local meteorological conditions, the geographic setting of the city, the amount of tree canopy covering the canyon floor and distribution, tree typology, the water availability for trees and the tree health condition" (Segura et al., 2022, p. 2). The authors also point out, that the effect of street trees differs from the effect of trees in urban parks and green patches, making it necessary to differentiate between studies

on trees' effects. Considering the shading and evapotranspiration provided by tree canopies, Loibl et al. (2021) emphasised the cooling potential especially were buildings are moderately increased, leading to higher sun-exposure of facades in densification scenarios. Thus, the authors recommend to

> focus urban greening on street levels, "in order to increase evaporation and humidity, as well as decrease heat exposure through shading" (Loibl et al., 2021, p. 20).

Referring to the tree typology, Back et al. (2023) show that the height of trees is important: The higher the tree, air flow increases while air temperatures decrease.
In terms of residents' perceptions, Byrne et al. (2016) reported respondents' high levels of perception of shade provision and temperature reduction as health contribution of trees. Despite a reported impression of disadvantageous maintenance costs of street trees, the authors recommend street trees amongst other forms of urban green infrastructures as policy response to the UHIE.

Leisure and recreation in the interviews
Participant D draws the attention to the impact of street trees on temperature reduction in areas with little green space and many built structures (C.4.1, ID 16). Looking at two distinct neighbourhoods of Amsterdam from above, the participant emphasises the quality benefits of green space for the eco-system as well as for the urban climate. They state that trees can have cooling effects of evapotranspiration, parks may offer social areas, but (potentially private) grass lawns are used less in absolute numbers than parks and do not provide ecosystem services as high as, for instance, trees. Participant L raises the social aspect of green space use, identifying a social differentiation in who has the ability to reach recreational areas outside the city. For this reason, green space areas would need to be incorporated into the urban fabric 'in front of your doorstep'. This could provide a more equal access to green space (C.4.9, ID 22). On the macro scale, respondent D features densification of existing urban environments as a tool to enable reforestation outside of city areas.

E.2. WATER, flood and rain

Physical infrastructure and economic prosperity in literature
The location of densification developments is crucial at the outlook of flood vulnerability. Duy et al. (2018) exemplify this in their study on Ho Chi Minh City. This was related to poor observation of altitude knowledge in urban drainage systems. Adaptive measures cannot keep up with damages in flood prone development areas of the low-lying city. In their assessment of diverse CA interventions in public spaces across European cities, Ricart et al. (2022, p. 20) made the observation, that

> "[...] there is a lack of attention to landscaping promotion, while water management attributes are limited to runoff control and water surplus issues."

But already the mere increase of sealed surfaces lead to higher pluvial flooding exposures in CC scenarios. In the comparative study of Skougaard Kaspersen et al. (2017), the increase of impervious surfaces in four European cities lay between 7 to 12 % in the past 30 years of their development. Increasing densification might amplify this issue. On the other hand, Z. Zhang et al. (2023) used the examples of Hong Kong, Miami and Jeddah to state that CA interventions (here, the flushing of toilets and cooling with sea water) was much more feasible in compact cities as the sprawled form of Jeddah made this approach inefficient.
Green spaces, such as green roofs, parks and small pocket patches and trees not only have a cooling effect through evapotranspiration but also may provide space for water storage and ground permeability in cases of extreme rainfall. In Rosenberger et al. (2021) green roofs, even though retaining water, may not be able to withstand future CC rainfall scenarios. However, they still have delaying capacities for drainage, making them beneficial CA infrastructures. The risk of floods and rainfall were discussed in Morelli and Cunha (2021), establishing flood vulnerabilities of various transport modes. The authors conclude that next to building layouts, the development of more resilient transportation can provide added resilience of physical infrastructures during rain events.
And also Bruwier et al. (2020) highlight the potency of building coverage and urban form on the rainfall storage capacity and outflow discharges (p. 10). In this light the potential cost of densification may rapidly also lead to financial damages. Providing direct advice, Li et al. (2021, p. 14) conclude that

> "the conveyance porosity and the number of streets along the direction normal to the main flow offer an opportunity for new developments which do not increase flooding severity."

Moreover, were flow paths already existed, they should be maintained as "fragmenting a flow path into several ones [...] increases the flow resistance" (Li et al., 2021, p. 14). From a very pragmatic side, Fitobór et al. (2022) looked at the flooding risks of manholes. Depending on CC scenarios, they conclude that 12 % to 31 % of manholes would be at risk of flooding in extreme rainfall scenarios (p. 6). This can have consequences for sewage overflow and thereby impact resident health particularly in lower lying areas.

Actual quality and safety of physical infrastructure in the interviews

The increase of sealed surfaces through building construction as densification strategy was mentioned as drainage barrier by the respondents (C.4.4, ID 3). However, the specificity to Amsterdam is the topographic distinction between a synthetically elevated center and the lower lying outer areas (simplified). This was subject in the statements of several of the interview participants. Respondents G and F highlighted the criticality of the area choice for densification. Lower-lying areas that are already more susceptible to floods would have an increased vulnerability if additional housing units are build (C.4.4, ID 4; C.4.3, ID 9, ID 12). Moreover, the vulnerability of electricity infrastructure and electric infrastructure such as data centers in particular in flood prone areas was identified as challenging the planning and physical layout of the grid as certain areas have to be avoided (C.4.4, ID 5).

A population increase within the low-lying areas will also lead to challenges for the provision of potable water (C.4.9, ID 26). This is a point where one respondent saw an opportunity to include rainwater storage systems. This water could be applied in flushing systems or other grey-water use applications (C.4.4, ID 12). Lastly, this matter in their view also provided for the need of a general budgetary balance between precautionary CCA and present and future CCM and social function demands (C.4.3, ID 9).

Economic relations impacts and social differentiation in the interviews

To use densification as an opportunity to incorporate flood prevention and mitigation measures can be seen in the statement of respondent E. Such measures might be less costly and quick-wins in public space design. Some solutions in risk areas would however need financially and technically challenging solutions, such as the elevation of the ground level (C.4.2, ID 27).

The severity and exacerbating inequality of flood risks, particularly in lower areas of the city have been accentuated by participant F. Lower lying neighbourhoods already faced the need to pump out inundated basements and the consequent damages after extreme rainfall events. For these reasons, the protection levels will have to scaled up if such areas are densified (C.4.3, ID 8, ID 9). The respondent stressed the power that such events, which will recur more frequently with CC, may have on property prices and values. On top of the costs of recovery from extreme events may come these negative property value developments (C.4.3, ID 11, ID 12). This might pose another factor of urban inequality as lower income populations have a geographic and topographic correlation with lower lying areas, and also areas under consideration for densification (C.4.3, ID 13). The participant called for precautionary planning, including dissemination of residents and municipal officials and participation in the planning process to prevent dissatisfaction with the authorities and political institutions (C.4.3, ID 10, ID 12).

The connection between the water system and impacts on economic can be seen in the statement of interviewee G, who describes the construction of basements and the implications for property values and the hydro-logical system. The construction below the ground affects the options for water storage during rainfall events and creates a flood risk for the cellars built. Additionally, with vast numbers of sealed basements built, the groundwater flow is obstructed, which is a topic which is regulated in the land use plan. However, the living unit space increase as well as the private storage space increase raises the property values. For this reason, the respondent urges for stronger regulations of the use of underground space to prevent added vulnerability and interventions into the hydro-logical system (C.4.4, ID 14).

Actual health and actual quality in literature

Other adaptability and CA interventions such as retention or cooling had not been in focus. But, the interventions the authors evaluated did create social impacts such as social cohesion or recreational activities of residents and some addressed vulnerabilities of distinct resident groups. For these groups the actual quality of the built environment was improved by the CCA-sensitive urban development.

E.3. Mobility

Social differentiation and autonomy in literature

In general, Mouratidis (2018) questions the sustainability and livability of compact neighbourhoods for citizens if the necessary traffic infrastructures and mobility options are not set in place. Comparing more cyclable and walkable European cities to younger, larger Asian city developments, the author raises notions of lack of access to nature, autonomy, low environmental amenity value and leisure options if these areas were to densify. Moreover, they state the general necessity of the placement of employment options and amenities for a compact city environment to be beneficial.

Urban areas in particular may lead to social differentiation in mobility, where CC and densification adversely affect outdoor thermal comfort at pedestrian level as seen above. As walking is a high-accessibility and -availability mode of transport (Vich et al., 2019), this may disproportionately affect vulnerable groups.

In the analysis of the four data items connecting mobility to autonomy, the autonomy of residents was defined by mobility costs, household income levels and urban form allowing for affordable transport modes and parking (Everett et al., 2018; Kaza, 2020; Muñiz & Dominguez, 2020; Muñiz & Rojas, 2019). The effect of mobility mode choice in the future and population density was subject in the study of Clark (2013). Where individual motorised traffic lead to increased road congestion, rents went up. The provision of sustainable, shared public transport in this sense affected the availability of housing for lower income groups.

The effect of income levels on GHG emissions has been a result of the case study of Muñiz and Rojas (2019). For the area of Gran Concepción, Chile, they established that instead of population density, income differences are a determinant of individual GHG emission variability from transport and households. Under the imperative of a distributively just sustainable development, this result adds to the discussion of how much income inequalities account for patterns of unsustainable use of energy in households and private mobility. In the study of Muñiz and Dominguez (2020) one year later, the potential of higher income residents to move to less dense, or less regulated areas was stated.

In the case of the impacts of the ET on autonomy, I reasoned a connection especially with mobility. An example is the study by Rosenberger et al. (2021) on sustainable water management during densification and CC. The authors conclude that "[p]orous pavements offer a straightforward possibility to increase the infiltration of areas like footpaths or cycle tracks" (Rosenberger et al., 2021, p. 9). As cycling and walking are low barrier means of mobility, they may provide a simple tool to increase residents' autonomy, which accounts for low emissions and may be easily integrated in dense urban form. However, potentially adverse impacts on autonomy may arise from increased heat on surface levels, inhibiting especially cycling and walking, which was discussed by Segura et al. (2022, p. 17) and Palusci et al. (2022, p. 1). This applies ever more so under weather conditions to be expected due to CC.

Autonomous mobility in less densely populated areas such as suburban or shrinking neighbourhoods becomes a question of viability. An exemplary study was conducted on the star-shaped city by Pierer and Creutzig (2019) who found this urban form to provide access to public transport and green space alike, alleviating also the UHIE and facilitating CCA. But also social differentiation and living standards due to ownership comes into play where mobility during the ET is considered. Byrd and Ho (2012) as well as Ko et al. (2017) discuss the feasibility of a grid integration of electric vehicles (EV) and solar PV. Their conclusions are that benefits arise in low or medium densities, rather found in suburban areas. This becomes a question of ownership, social differentiation and living standards if the financial costs of suburban living and EV are considered.

Access to public services, autonomy and physical infrastructure in the interviews

Densification opens up the opportunity of proximity, reducing travel times and distances in contrast to sprawled urban form and increasing accessibility of public services and autonomy. If infrastructures allow, this increases walkability and cycle-ability (C.4.2, ID 6, ID 7; C.4.4, ID 20; C.4.1, ID 21), next to the viability of public transportation (C.4.2, ID 7).

Respondent G imagines that densification for instance in the form of a *15 minute city* may hold beneficial impacts on health, accessibility and autonomy (C.4.4, ID 22).

In the conversation with participant H, they used the example of the US-American urbanisation model and the implications for women living in suburbs to underline the equalising effect for women's, children and the elderly's access to public services: "[if] where you live, you can get out of your house without having a car, [...] without being car dependent, that's super important. For women, but also for children,

and young people, or for elderly who cannot drive anymore" (C.4.5, ID 11).
That proximity, walkability, close amenities, green space and public space of densification could increase the autonomy of "people that are more at home, not necessarily women [...] but [...] people that are more at home" was also raised as potential benefit of densification by participant K (C.4.8, ID 23). Similarly, participant E perceives densification as potentially relieving pressure from care-work tasks if the functions in the city are brought closer together, are accessible by bike or walkable. This may give room to the institutional side of emancipation of women, who have been the majority of care-workers in the past. A side effect of these means of transport are the benefits for actual health of the residents (C.4.2, ID 24). And also participant D sees an opportunity for a changed distribution of care-work between household members or over the course of a daily routine through the proximity densification could create (C.4.1, ID 21).
Participant J summarises the notion of walkability which promotes the actual health of residents, but also counters the standpoint of accessibility autonomy benefits for residents. This ideal might remain an empty promise, if the houses are being build, but the investments into public transport do not follow. This would lead to the counter-effect of higher resident numbers in areas of low accessibility (follow-up communication on C.4.7, ID 19).
Respondent J further gave the example of a neighbourhood team which had been established, but which was not accessible to groups with lower mobility capacities as the institution's building did not provide a parking spot for handicapped people, "because we did not have enough parking spaces in that neighbourhood." In this way, social inequalities can propagate as social support to for instance groups of lower mobility cannot be offered properly if the groups that need it cannot reach the established facility (C.4.7, ID 18).

People walk and cycle more and walking and cycling, of course, is a more inclusive way in mobility than cars. And it's a very difficult discussion because this is the theory, but in practise the areas which are suitable for walking and cycling are the most gentrified areas. Which is not inclusive at all. There's quite . . . this is actually quite a paradox.
(C.4.1, ID 12)

Participant I refers to the opportunity in densification to create proximity of public services as well as social networks. However, these might also be interrupted if the mobility infrastructure is not systemically and systematically provided for to account for increased population numbers and the densified built environment, which might lead to obstruction of former traffic mode flows (C.4.6, ID 19). In this manner, the autonomy of the residents may be in- or decreased. On the downside, depending on the mode of mobility, proximity can also infer less active daily routines. Moreover, the regulation of car-traffic may affect residents in their employment. Job groups working outside public transportation hours or accessibility, or in the need of equipment transportation depend on motorised transportation. Establishing car-free cities or low-car use areas without the simultaneous provision of sufficient public transport or car permits for business that are car-dependent can hamper such to serious extent in the conduction of their (self-) employment. Therefore, the participant also emphasised the need of systems thinking, to not only provide options of public transportation, but also to ensure that public amenities are provided and employment positions still viable to reach (C.4.7, ID 17).
Participant K also raises these issues and calls densification "wishful thinking" if it is seen as the solution to [all] societal problems. While it may improve "the access to institutions, to healthcare, [...] or to jobs, so that people can also, with a low income, or without a car, have a job in the neighbourhood", the facilitation requires observation of the impacts. In particular, the respondent emphasised that issues would be strengthened if created job opportunities would not be equally distributed over income groups. For instance, densification is driving production activities outside the city boundaries, which are not easily accessible, instead of locating them "ideally [...] around the corner" (C.4.8, ID 25, ID 29).
The trade-off between mobility and green space has been identified by participants D, H and L. The reduction of parking space and individual car mobility and the inclusion of small patch greening would enable the parallel increase of housing and green space in city areas (C.4.1, ID 15-17).
Spill-over of traffic from denser areas to surrounding neighbourhoods was mentioned by participants I and D (C.4.6, ID 15; C.4.1, ID 6). The interviewees emphasised that these shifts of traffic flows to surrounding areas may lead to the fact that residents in adjacent areas, who might not benefit from densification, may in this regard suffer from the consequences of an increased use of their neighbourhood infrastructures.

Leisure and recreation and living standards in literature
The importance of green infrastructure for these modes of mobility were included in Kabisch et al. (2021) and their observation of leisure and transit uses of park areas at various temperatures. The park layout and typology such as options to linger, hide from solar radiation and not lastly the provision of short-cuts in otherwise hot surroundings were observed.
In terms of location choice, Muñiz and Dominguez (2020) suggest a social self-selection of higher income families for low carbon emission cities. This link provides hints of social differentiation and living standard pre-determination also for future CC development scenarios.
Lastly, the recent example for potentially arising inequalities due to mobility choice options was subject in the study of Khavarian-Garmsir et al. (2021) who found a failure of health safety on public transport systems (p. 9).
Creating walkable urban areas may also be a form of CCA risk plans: as Morelli and Cunha (2021, p. 8) highlight, that

> "providing proper density to cities and incentivizing residential development in biking or walking distance to services and job opportunities may limit the problems caused by events of this nature [floods, extreme rainfall events]."

The proximity to amenities allows walkability and cyclability, which are flexible in their route choices and traffic directions. Also Perera et al. (2023) conclude that topography needs to be considered in densification developments. Not only in the cases of flood vulnerability, but also the UHIE, the impact of densifying in already hotter climates exacerbates heat vulnerabilities.

Actual health and social quality in the interviews
The proximity created through densification - if amenities and facilities are included, together with access to walkable pathways and public transport may therefore increase health and well-being: "If you create proximity, it's easier to walk to the facilities you need, so it promotes an active lifestyle, [...] so in an abstract way, densification benefits well-being" (C.4.7, ID 27).
Also respondent G mentions the potential benefits that a densified environment could pose. On the one hand, the density of functions and proximity might facilitate caring for vulnerable groups in extreme situations such as heat periods. On the other hand, denser areas might have stronger, small scale community entities. This might facilitate CCA initiatives but also volunteer work and care-taking of elderly, homeless and children (C.4.4, ID 8, ID 19).

E.4. Heating and cooling

Well-being, actual health and housing quality in both perspectives
The high relevance of health indications in terms of heat and the UHIE provides a logical conclusion for the highest ET count to be located in the sphere of heating/cooling. This relationship was concluded by Bakhshoodeh et al. (2022) and Belcher et al. (2019) at the example of green facades or by Perera et al. (2023) for the increased cooling demand in their case study cities Madrid, Athens and Belgrade (p. 399). As Martilli (2014) state, the surface of the building to volume ratio highly predetermines the heating and cooling energy generation per capita. The authors observe that if the energy consumption can be reduced to certain levels, the overall cooling demand may reduce despite increasing mean temperatures due to the UHIE. Finally, the authors compare this dichotomy with the local urban increase of air pollution resulting from urbanisation while globally in absolute numbers pollution levels may increase less than if urban sprawl was pursued. This relationship also represents one of the local-global contrasts leading to social differentiation. To prevent adverse impacts, one of the interventions for CCA they add is the vegetation and greening of the urban space. Mohajeri et al. (2019), even though at the example of a small village, showed the impact of building compactness on summer cooling demand in future scenarios. If the complexity of necessary ventilation, shading and radiation is observed, they certify reduced cooling demands despite urban densification.
Perera et al. (2023) point out the impact of human behaviour. In their study occupant behaviour relates strongly to their thermal sensation. The cooling needs are not only due to temperatures, humidity and air velocity, which can be impacted by CC and urban form, but also by occupant activity and clothing level, determining well-being. While this results in the author's focus on commercial buildings to reduce uncertainties, it gives important CA indications for the inclusion of human behaviour into the

assessment.
The strong impact that architecture can exert on well-being and heating and cooling behaviours is subject to the study of Salvati and Coch (2021). Assessing Mediterranean climates, they stress the importance of building ventilation, humidity regulation and protection from accumulated solar radiation to prevent heat stress, excessive cold or heat seasons. X. Liu and Sweeney (2012) name one simple densification attraction: the energy efficiency of apartments. This they infer from compact building construction and decreased ventilation, diminishing heat loss. As established above, the reduction of ventilation may create positive like here, or negative second order impacts.
Next to green facades, the literature also identifies the potential cooling benefits of green roofs. Not only increasing urban green areas, providing evapotranspiration and storm-water management, Wright et al. (2021) address the insulating effect that green groofs may provide, decreasing cooling energy demands in summer times. In their study, productive green roofs, used for agriculture, may therefore not only benefit well-being, health and income, but also the living standard of the residents.

Respondent G raised the attention to the feedback impact that the increase in the number of air-conditioning units (AC) has on the temperature development within the city and the demand on the electricity grid. Population groups that depend on AC during heat periods may be particularly vulnerable if AC cannot be sustained in a densified, warmer environment (C.4.4, ID 11, ID 16).
Respondent E emphasises the potential of insulation improvements during densification. This improvement of the housing stock would be an opportunity to increase health, well-being and lower the recurrent energy bills of residents (C.4.2, ID 13).
The overlap of the ET and densification in regards to heating was one of the main themes in the interview with participant I. The connection of new development areas to existing district heating networks in the city is an opportunity they identified next to the use of heat-cold storage. Effective on the building scale, this solution is cost effective but requires financial investment and may be a solution for office or other larger buildings (C.4.6, ID 5). This may be connected to the integration of heat symbiosis from corporate and industrial buildings to objects with residential use (C.4.8, ID 3, ID 4).
The decision and investment for more sustainable heat sources, connection to the district heating network or installation of hot/cold-storage systems is an additional barrier for residents of lower income and tenants. However, if the housing owner takes this step, the improvement of the housing quality may become very beneficial to the living standard and health of the residents in the long term, after a period of nuisance in the construction and renovation phase (C.4.6, ID 10, ID 11). This relationship and ownership issue can be seen as one of the symptoms and causes of social differentiation and lack of or opportunity of participation in decision-making in the heating transition.

Living standards, income, social differentiation in literature
The strong association of heating and cooling with well-being and autonomy impacts is related to the cooling efforts during an increased UHIE, the moderation of colder climates due to the UHIE in dense urban areas in moderate climates as well as the lowered autonomy due to increased cooling costs, especially for residents living in houses with lower insulation quality (X. Liu & Sweeney, 2012, p. 10).
As an interesting factor of communal living spaces, Ahmadian et al. (2019) raised the significance of energy infrastructure and appliances in shared living spaces of compacted housing blocks (p. 147). Good management and communication are necessary to facilitate reasonable and just usage of energy in shared facilities.
Human behaviour and autonomy are discussed by Muñiz and Rojas (2019). They observe that next to mobility behaviour changes, energy consumption at the household level increases with household income level.
Heating and cooling modes, choices and autonomy are detrimental for thermal comfort and urban equality. As Butters et al. (2020) state "[w]hilst business districts can at least afford to pay for cooling, UHI[E] is most harmful for low-income contexts with overcrowding and no-air-conditioning. It is the poor who most often must work and move around outdoors, or else in poorly climatised buildings. [...] The choice of urban form thus also is a question of equity." (p. 211). Similarly, Pramanik et al. (2022) weights the reduced, low adaptive capacity of poor residents while their living standard and household conditions would need them to be adaptable in particular to changing climates and extremes.
The energy expenses created through cooling pursuits were described by Miner et al. (2017, p. 193). The authors concluded that in the case of the UHIE as an extreme event and hazard for especially vulnerable

groups,

"the most likely strategy pursued by individuals would be to invest in more air-conditioning capacity, which will typically increase household energy consumption, exacerbating the issues [i.e. the self-reinforcing nature of the UHIE]."

Approaching densification as an opportunity to incorporate emerging technologies, Martínez Reverte et al. (2022) evaluate the use of fuel cells for heating. While initial investments are high and therefore qualify the solution as another source of social differentiation. However, primary thermal and electric energy demands could be covered. For lower investment capacities, the authors nonetheless recommend retrofitting of buildings to improve their energy performance.

Social differentiation and energy expenses in the interviews

Densification can provide an opportunity to install collective heating and cooling systems in neighbourhoods and blocks, also in lower-income neighbourhoods and in line with the municipal policy of "unequal investments for unequal opportunities" (C.4.6, ID 13). The inequality of the heating transition as part of the ET, was stated also by participant I. The upfront investments in lower-income areas might not be opted for against other, especially short term day to day expenditures. The uptake of more sustainable heat sources simultaneously to densification developments in the neighbourhood may therefore be decided against, due to unaffordability. Also distrust into political institutions and the municipality may hamper such interventions (C.4.6, ID 22).

Moreover, heating was claimed as one of the areas of the ET, where building ownership is pivotal. For the ownership communities, less emitting energy sources for heating are frequently linked to investments into building stock and backlog in the renovation. When these obstacles are overcome financially, the voting processes in the communities may be challenging to the uptake of new heating solutions. In these cases, the municipality would like to connect ownership communities to each other and offers training for knowledge exchange (C.4.6, ID 8, ID 9). Respondent J reflected on the chances for community interaction in the neighbourhood if energy sourcing and storage are managed in local systems. The ownership of energy production communities may lead to a feeling of participation in the ET and increase community cohesion. However, the inclusion of residents in social housing and low-income owners may lack behind, which could propagate feelings of exclusion (C.4.7, ID 21).

Finally, the risk of gentrification and driving out of lower income groups from densified areas with a higher quality housing stock has been stated by respondent J. As "densification and more energy reliant buildings [...] are creating housing which is having a higher quality, [the current/original residents ...] have to move so the social interaction between groups could fall apart. [...] And we don't have the solution yet, [...] [w]e're looking at how can we provide affordable places and stores and community centers that keep the social infrastructure intact" (C.4.7, ID 5). But, it is a thin line, as areas with lower energy performance buildings could profit from densification if the densification made actions promoting the energy performance viable (C.4.7, ID 20).